Paper - 2

[CN → PYQ → Book ± assign+

		Fi	B	Imp	Marks
(I)	Delocalised covalent bonding	1, 3, 4 Comp (7/10)	7 (once)	N. Tiwari	10 - 15
(II)	Rxn mech	1, 2, 3, 4 Comp eg.	5, 6, 7 (twice)	NTiwari	~130 [Subs ~40, Elim ~20, add^n ~60] [R^N ~70 - includes subs] [Named Rxn - link w intermediates, add^n]
(III) →	Pericyclic + photo	1, 2, 3, 4 Comp eg	5, 6, 8, 7 Comp eg.	Jagdamba Singh	60 - 80
(IV)	Polymers & Biomolecules	2 (twice)	5, 6, 7, 8 Comp (7/10)		50 - 60
(V)	Named rxn & R^N	1, 2, 3, 4 (mostly) Comp (4/10)	5, 7, 8 (rarely)	N. Tiwari	30 - 50
(VI)	Reagent	1, 2, 3, 4 Comp (6/10)	5, 6, 7, 8		50 - 70
(VII)	Spectro	2, 3, 4 (rarely)	5, 6, 7, 8 comp (eg)	Kalsi	70 - 80

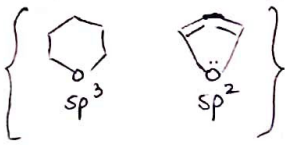
(I) Electronic effect = e^- disp towards a particular atom.
Temp (electromeric) Permanent (I, M, HC)

(A) **INDUCTIVE EFFECT** – relatively permanent disp of σe^- in a σ bonded compound towards more EN atom

- (-I) $\propto$ s character $\propto$ EN $\propto$ (+ve OS) $\propto$ acidity (CB stab)
  [$-C\equiv CH > -C=CH$] [$F > Cl > Br > I$] [$NO_2 > NO > NH_2$]
- (+I) $\propto$ (# substituents) [$Me_3C > Me_2CH- > MeCH_2- > $]
  $\propto$ basicity ($\uparrow e^-$ density)
  * EN order H > D > T
  (+I) order H < D < T
- (±I) $\propto \frac{1}{\text{distance}}$

(B) **MESOMERISM** = delocalisation of πe^- due to adjacent π, lp, +ve, -ve, odd e^-, thus leading to conjugation.

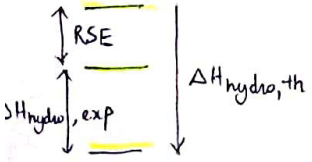
- π-π strongest, distance law not applicable
- Conditions: Planarity, equivalent orbital energy.



* Bond length order factors :-
① orbital energy
② EN

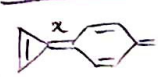
R = $NH_2 > OH > F > Cl$ (order of π)

- **Heat of ~~hydrogenation~~ hydrogenation**: If a compound is already Resonance stab, its E is lower compared to non-resonating form. $\therefore |\Delta H_{exp}| < |\Delta H_{th}|$



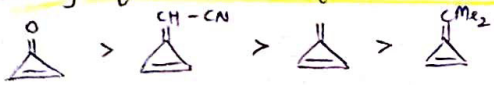
$|\Delta H_{th} - \Delta H_{exp}| = RSE$
Resonance Stabilisation energy.

- **Dipole moment**

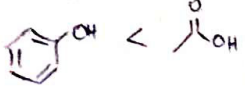
→  x rotational barrier only 7 Kcal. Why?

→  significant DM, Why?

* Stability of a charge inside ring depends also on stability of counter charge outside ring.

→  aromatic ch.

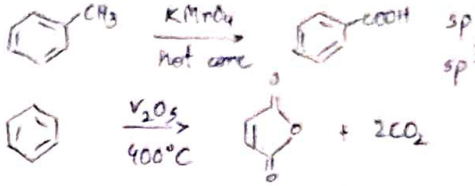
- **Acidity**

→  b/c 2 symmetric 'O' stab -ve in acetate, but -ve goes on 'C' in phenoxide.

→ $-M-I$ = acyl derivatives
$+M>I$ = $-O^\ominus$, RCBakernathan effect)
$+M>-I$ = $-OR$, $-NR_2$, $-Ph$
$-I>+M$ = $-X$
$-I$ $-NR_3^\oplus$

⇒ **AROMATICITY** = exceptional stab of cyclic planar comp having $(4n+2)\pi e^-$ in conjugation over non-aroma/acyclic counterparts

- Normal OA do not work, strong OA breaks ring



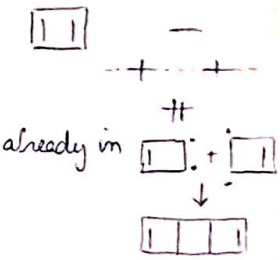
- Energy of π MO in cyclic compound is given by :- $E_j = \alpha + 2\beta\cos\left(\frac{2j\pi}{n}\right)$

α = Coulombic E = E of single e^-
β = overlap E
n = # orbital in conj
j = 0, ±1, ±2 ... total n

$E_{conjugated} = N_1E_0 + N_2E_{-1} + N_3E_{+1} + \dots$
$E_{unconj} = N(\alpha+\beta)$ $N = \Sigma N_i$ = total e^-
$RSE = E_{conj} - E_{unconj}$

Eg: Benzene — $\alpha-2\beta$, — — $\alpha-\beta$, ++ ++ $\alpha+\beta$, ++ $\alpha+2\beta$

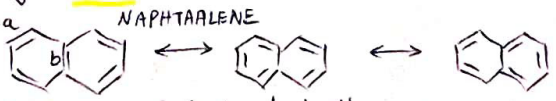
$RSE = 6\alpha + 8\beta - (6\alpha + 6\beta)$
$RSE = 2\beta$ i.e. 2X overlap E
$\therefore$ Thermodynamically stable



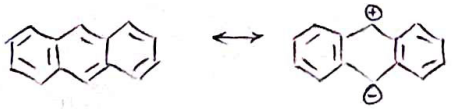
- No unpaired e^- in ABMO → Kinetically stable, but in anti-aromatic, $2e^-$ in non-bonding make it kinetically reactive. No conj. stab $\therefore$ Thermo unstab too.

→ Alternant hydrocarbon (equal BMO and ABMO numbers)

* Benzene has highest aromatic stab E (ASE) per ring (-36 kcal)

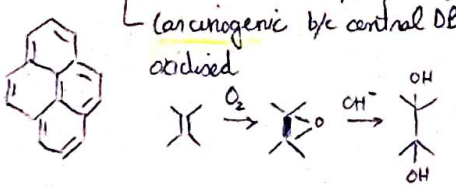
* NAPHTAALENE 

b has more single bond ch-than a $\therefore$ b > a

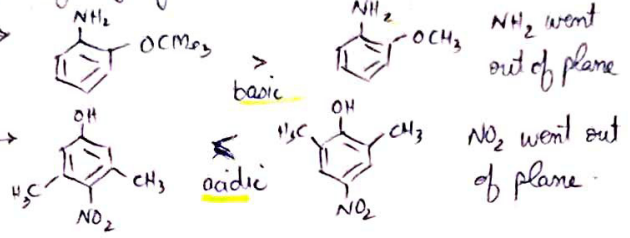
* ANTHRACENE  significant contri b/c 2 benzene rings

$\therefore$ DM of anthracene (0.12D) is v. high b/c Hydrocarbons do not show DM generally.

* PYRENE [Aromatic (count peripheral) (carcinogenic b/c central DB oxidised

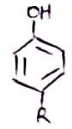


False steroid.

- $H-A \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} H^+ + A^-$ For stronger acid
  $k_1 \uparrow$ (weak H-A bond) or
  $k_{-1} \downarrow$ (A^- stabilised)
- +M / -M is most powerful at para position.
- o-nitro benzoic acid more acidic than para b/c CB stab by hydrogen-B.
- SIR → 
  NH_2 went out of plane
  NO_2 went out of plane.

(c) HYPERCONJUGATION πe^- delocation w σe^- of C-H at α-position wrt DB or charge ≡ Second order Resonance or No-bond resonance b/c separated H^+ remains part of molecule w/o actual bond.

based on symmetry. Trans less SH, most stab.

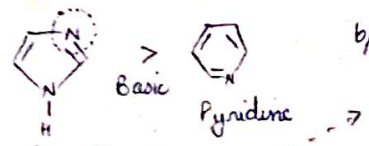
O/p 
R = CH_3 < Et < $CH(Me)_2$ < $C(Me)_3$ acidic ch.
b/c αH 3 2 1 0

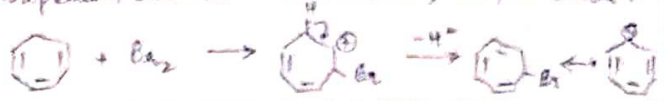
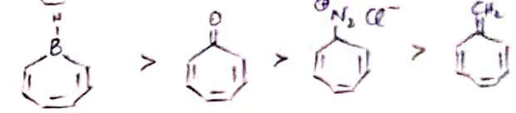
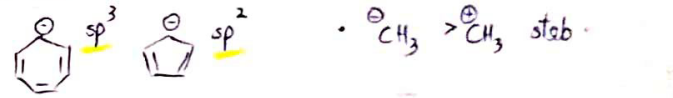
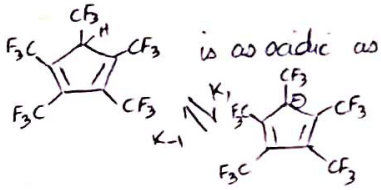
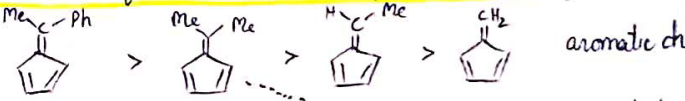
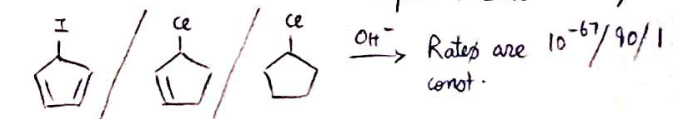
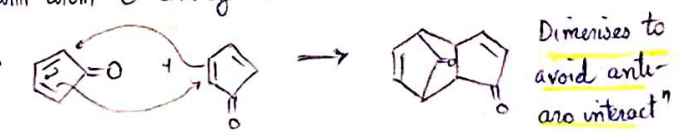
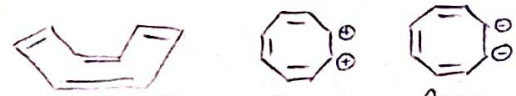
m 
R = $C(Me)_3$ < $CH(Me)_2$ < Et < CH_3 acidic ch
b/c no Baker nathan, only (+I).

- Reverse hyperconjugation → only in CF_3 b/c F^- can stab -ve charge. F^- = v. strong m' director in E^+ subs.

- 
  Thiophene > Furan > Pyran
  ASE −31 −20 −16.2

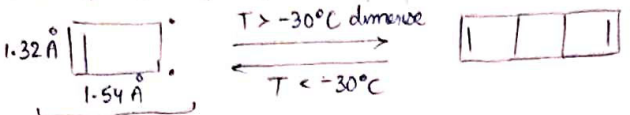
① S is least EN - easily donates lp (−26)
② S is ep accepter too in d-orbital. (−5)

- 
  b/c N has (+ve) ch. over and above its concerj. lp.

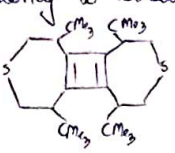
- Tropelium Bromide = water soluble, CCl_4 insoluble.
- 
  ADDITION ELIMINATION (not SUBSTITUTION)
- 
  Tropolone > Tropone > Bromo-tropone
  Aromaticity
  (Formation from Carbene)
  Stab of +ve oxide ring depends on stab of -ve outside ring.
- 
  B = excellent Lewis acid.
- 
  $^{\ominus}CH_3 > ^{\oplus}CH_3$ stab.
- 
  $K_a = \frac{K_1}{K_{-1}}$ (K_1 high) = v. high / (K_{-1} neg.)
  all 'C' already have δ+ and welcome circulating -ve.
- 
  pKa 24 21 14
  1 2 5 = # stable canonical forms w/o disturbing aromatic ring.
- 
  aromatic ch
  Substituted fulvenes are more arom. b/c +ve outside stab by more substituents → (Fulvene formation from Carbanion)
- 
  OH^- → Rates are 10^{-6} / 90 / 1 const.
  ($^{\oplus}$anti-arom $C^{\oplus}$ stab by +M
- 
  Dimerises to avoid anti-aro interact"
- 
  Non-aromatic Arom. Arom.

* 4 membered ring

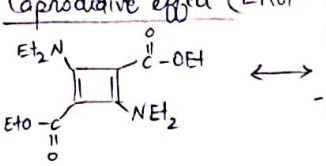
X ray crystallography @ -50°C reveals rectangular shape.



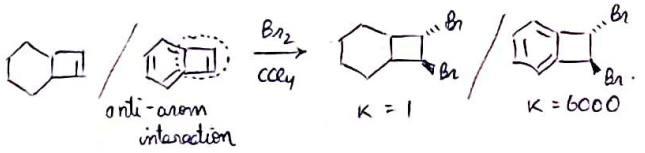
↓ dimerisation tendency to isolate it :

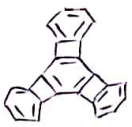
① Bulky subs.  @ Room T isolated

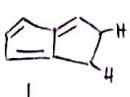
② Caprodative effect (ERG - EWG back to back)

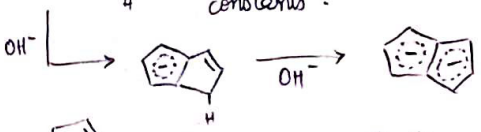


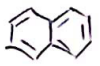
No e^- exist inside ring.

- 

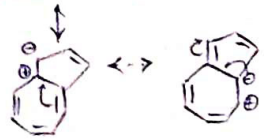
-  $3H_2$ → Central ring hydrogenates to end anti-arom for all 3 4m rings.

-  is strongly acidic for both dissociation constants.

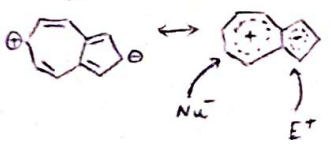


-  isomer of 

AZULENE (Dark blue) — NAPHTHALENE (White)

①  Canonical forms like this rep. e^- transition from 7m to 5m ring resulting in ΔE

$\Delta E = E_5 - E_7 = \frac{hc}{\lambda}$ → $\lambda \sim 490$ nm (blue)

② Exceptional dipole moment of Azulene is due to charge separation. 

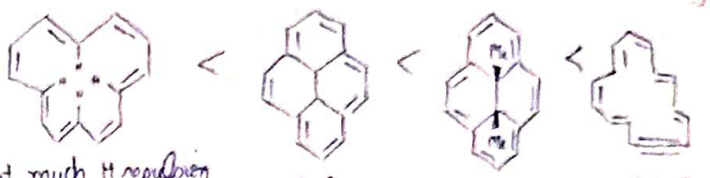
③ Azulene undergoes both E^+ and Nu^- attack.

⇒ C_nH_n ($n \geq 10$) ≡ ANNULENES

-  H-H repulsion make it non-planar

All 3 conen of $C_{10}H_{10}$ non-planar, non aromatic BUT last one can be made aromatic

 sp^3 C ⊥ interfere ῶ π circulation. AROMATIC

- 

Not much H repulsion ∴ [14] annulene is aromatic [$(4n+2)\pi e^-$ as well as planar]

Me-Me repulse & go out of plane

Triple bond

- [18] - annulene shows both aromatic and aliphatic properties b/c of conformational mobility (common in ring size >16)

Aromatic - negligible H repulsion

[$(4n+2)\pi e^-$ + planar]

Zig-zag structure

E^+ - bromination ✓

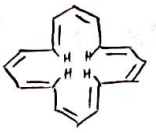
Addition rxn ✓

- [12] - annulene is non-planar (saved from anti-arom)

BUT → Anti-aromatic

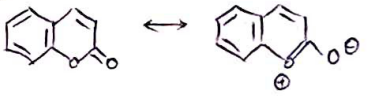
Internal H replaced by bigid sp^3

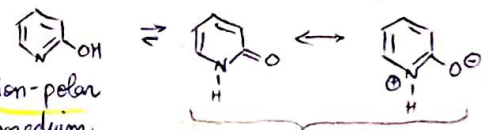
- [16] - annulene = anti-aromatic b/c neg. internal repulsion



⇒ MESO IONIC COMPOUNDS - always exist in charged form

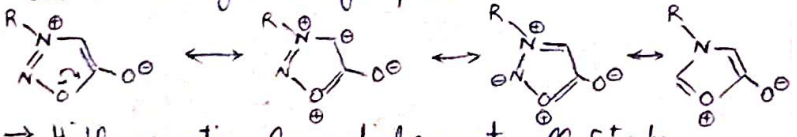
Aromatic b/c $(4n+2)\pi e^-$ circulation inside ring and relative charge is stab. outside ring.

- Coumarine (bio pesticide) 

- 2-hydro pyridine 

Non-polar medium — In polar medium

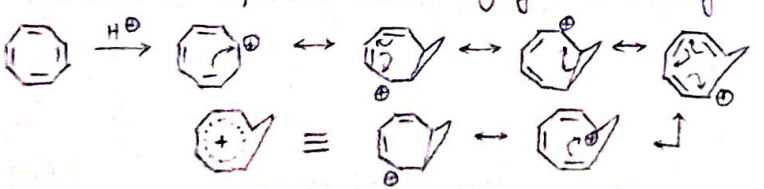
- SYDNONE - Cannot be rep by neutral structure - always exist as heterocyclic charged species.



→ Highly aromatic, large dipole moment, all E^+ subs rxns

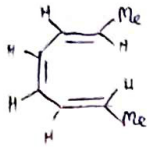
⇒ HOMOAROMATIC COMPOUNDS - charged comp. where πe^- circulate via form^n of 3C ring ῶ Sp^3 C ⊥ to molecular plane.

→ Low aromatic ch. b/c 3m unstable highly strained ring.



⇒ ISOMERISM

- No relation b/w E/Z and cis, trans
  - high priority same side

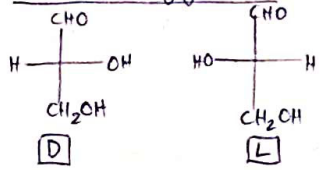


2E 4Z 6E - octa - 2,4,6 - diene

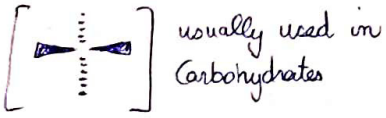
- Optical isomerism

① Plane polarised light deflected towards right → dextrorotatory (d)(+)
This is EXPERIMENTAL — left → laevorotatory (l)(−)

② Relative Configuration → wrt Glyceraldehyde (check last Carbon)



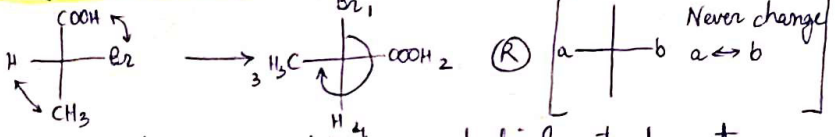
D L



usually used in Carbohydrates

③ R/S nomenclature [R = Clockwise]

- Bring lowest priority grp to bottom and rotate as per priority



→ Fisher projection
- 2n interchanges at chiral centre does not change configuration
- For >1 chiral centres, fisher projection is least stable fully eclipsed conformation.

④ Erythro and Threo (Erythro has similar groups on adjacent chiral centres on same side).

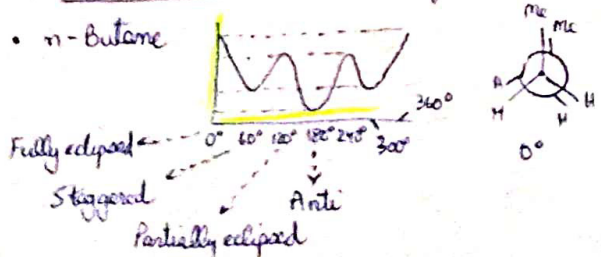
⇒ CONFORMATIONAL ANALYSIS

∞ conformers – free rotation about C–C bond [Most stable conformer = CONFIGURATION]

(I) ACYCLIC COMPOUNDS

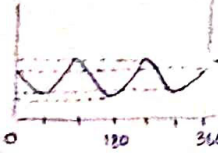
(a) NEWMAN PROJECTION [always draw potential energy diagram]

- n-Butane

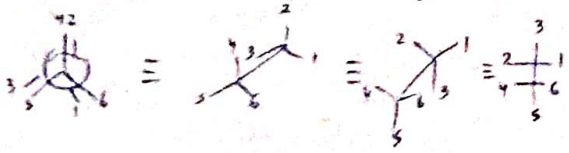


- 

Intramolecular HB
Stability gap is v. less

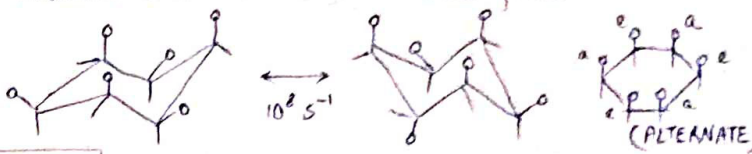


(b) SAW HORSE PROJECTION

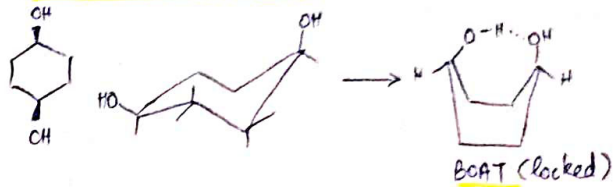


(II) CYCLIC COMPOUNDS

* Bayer's strain theory (109.5° – internal angle) suggests that 5m should be most stable (only 1.5° difference)
* However 6m exists in chair / boat form



* All higher bulkier than isopropyl go to eq. (CONFORMATIONAL LOCKING)

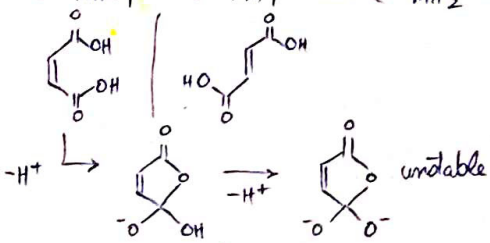


BOAT (locked)

- Polysubstituted cyclohexane → put Bulky @ eq. & then place others wrt it.
- Cyclopentane less stab. bc of envelope structure

- Maleic acid vs Fumaric acid.

$(K_{a_{MA}})_1 > (K_{a_{FA}})_1$ but $(K_{a_{MA}})_2 < (K_{a_{FA}})_2$



⇒ HOW TO STUDY ORGANIC RXNS

- TS vs Intermediate → all rxns have TS, only multistep rxns have intermediate (isolatable) ↳ actual compound.

- Rxn mech is studied indirectly to determine rds.

(I) STUDY OF RXN KINETICS

$A + B \underset{K_{-1}}{\overset{K_1}{\rightleftharpoons}} I \qquad C + I \xrightarrow{K_2} P \qquad \frac{dP}{dt} = K_2[C][I]$

$\boxed{\frac{dP}{dt} = \frac{K_1 K_2 [A][B][C]}{K_{-1} + K_2[C]}}$ ← SSA on I → $[I] = \frac{K_1[A][B]}{K_{-1} + K_2[C]}$

- When $K_2 \gg K_{-1}$ — I st step rds; step 2 fast → $\boxed{\frac{d[P]}{dt} = K_1[A][B]}$
- When $K_2 \ll K_{-1}$ — Step 2 rds → $\boxed{\frac{dP}{dt} = \left(\frac{K_1}{K_{-1}}\right) K_2 [A][B][C]}$ → K_{eq}.

* If all reactants appear in rate law, I st step eq., II nd step rds.

* But if some reactant in excess, difficult to assess its involvement in rds b/c it would not appear in rate law.

Rate $= K_2[X][Y] = (K_2[X])[Y] = K_2'[Y]$ (X in excess)

(II) ISOTOPY

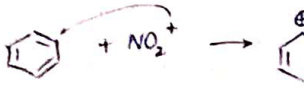
Vibrational energy $E = h\nu \rightarrow \nu = \frac{1}{2\pi}\sqrt{\frac{K}{\mu}}$

$\boxed{\nu_{C-D} = 0.7071\ \nu_{C-H}}$ ν decreases if heavier isotope.

∴ Breaking tendency of C-D < C-H → if C-H bond breaks in rds, replacing H by D should ↓ rxn rate.

→ Primary Kinetic isotope effect → Rate constant $\boxed{\frac{K_H}{K_D} \geq 7}$ changes by ≥7 if C-H breaks in rds.

e.g. $C_6H_6 + NO_2^+ \longrightarrow C_6H_5NO_2 + H^+ \quad \left(\frac{K_H}{K_D} = 1\right)$ Now we interpret:

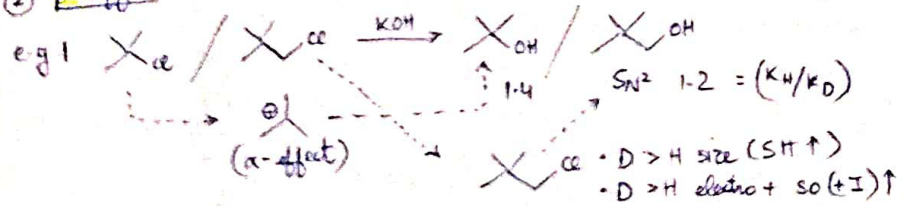
Step 1  ⇒ This is rds b/c arom lost

Step 2  → Faster b/c arom gained

→ Secondary Kinetic isotopic effect → $\boxed{\frac{K_H}{K_D} \leq 2 \text{ but } > 1}$

① α-effect – b/c of hyperconjugation

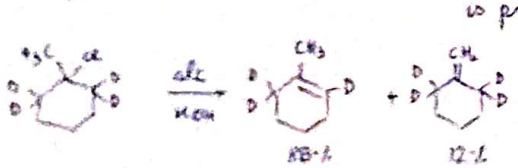
② β-effect – " " +M or electro (+) character. (α → β for $\frac{K_H}{K_D}$ value)

e.g 1 

eg 2 

R =	H	OMe	NO_2
(K_H/K_D)	1·4	1·2	1·78

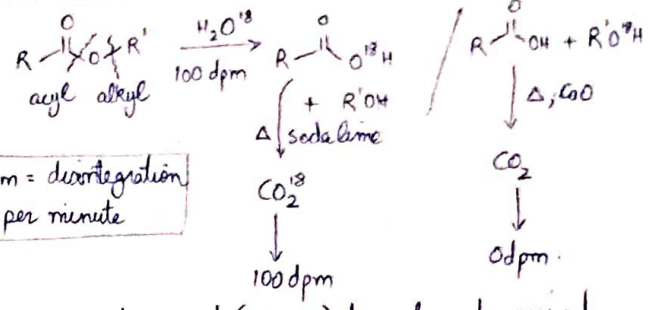
explain (K_H/K_D) => HC contri to stab ↑ when destab. factor is present → gives ↑ (K_H/K_D).

eg 3 

depending on final hyperconjugative stab of products.

(III) NON KINETIC USE OF ISOTOPE

(A) POSITION OF BOND BREAKING



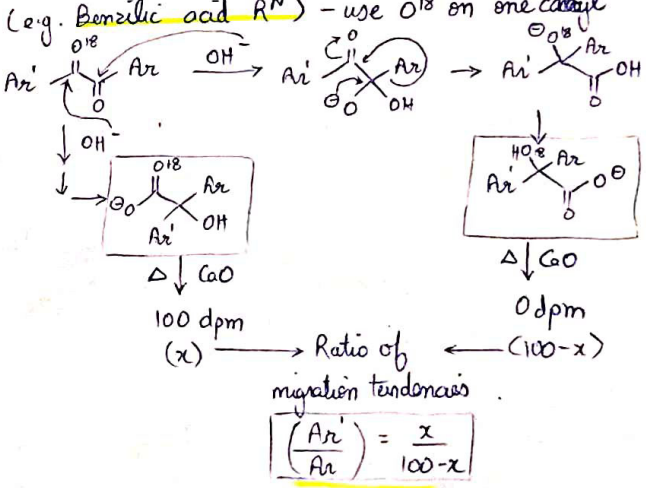
dpm = disintegration per minute

* If x dpm and (100 − x) dpm found, mixed mechanism. Thus acyl and alkyl mech depend on $C^{\oplus}$ stab on alcoholic part of ether.

R' =	3°	$HCPh_2$	Ph_3C	→ alkyl
	2°	alkyl	benzyl	→ mixed
	1°	Ar	Vinyl	→ acyl

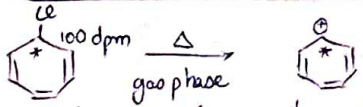
(B) RELATIVE MIGRATION TENDENCY

(e.g. Benzilic acid R^N) – use O^{18} on one carbonyl



$\boxed{\left(\frac{Ar'}{Ar}\right) = \frac{x}{100-x}}$

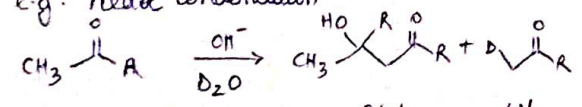
(C) SYMMETRY OF INTERMEDIATE



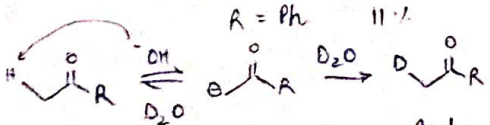
Radioactivity of charged carbon $= \frac{100 + 0 + 0 + 0 + 0 + 0 + 0}{7} = \frac{100}{7}$

(D) REVERSIBILITY OF TRACER experiment

e.g. Aldol condensation

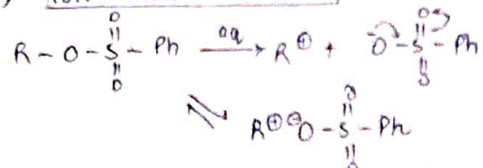


When R = H	94·1.	6·1.
R = Ph	11·1.	89·1.



* Extent of reversibility is equal to extent of Deuterium exchange. In this case, Ketone shows lower tendency for aldol pdt & higher tendency for deuterium exchange.

(E) **ION-PAIR FORMATION**

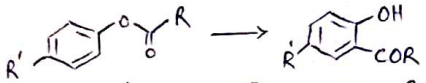


To differentiate both paths, use O^{18} and quench rxn in 30 sec, if all dpm from only ~~one~~ $R-O^{18}$ bond → ion pair rxn, if only 33% dpm in $R-O^{18}$ bond → dissociation pathway.

(F) **CROSSOVER EXPT**

- To distinguish b/w inter and intramolecular pathways in re-arrangement reactions by using 2 very similar reactants together. If crossover products are detected → intermolecular confirmed.

e.g. Fries R^N



(if R' was not present, trans isomer was also possible)

R' = Me or Et
R = Et or Me
1 : 1

→ Analyse products → Normal = Me Et & Et Me
→ Crossover = Normal + Me Me + Et Et

(G) **INTERMEDIATE TRAPPING** – by utilising properties of suspected intermediate in a process, e.g. to diff. b/w S_N2 and S_N1, add $LiClO_4$ to recover $C^{\oplus}ClO_4^-$ as salt. If no salt formed → S_N2 confirmed.

(H) **PRODUCT ISOLATION** – Single pdt → no intermediate
> 1 pdt → indicates intermediate

(I) **STEREOCHEMISTRY**

(a) Stereospecific → exclusively one stereoisomer as pdt. Single step rxn is always stereosp.

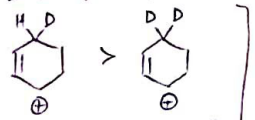
(b) Stereoselective → preferably one stereoisomer as pdt. i.e. 2 stereoisomers in unequal amount.

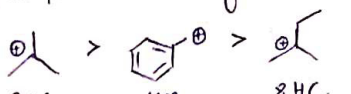
INTERMEDIATES

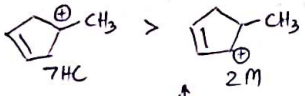
(I) CARBOCATION

- Trivalent sp^2 planar intermediate ⇒ vacant p orb. ⊥ to plane.
- Classical C (allyl, benzyl, phenyl, vinyl, acyl, tropelium)
- Non-classical (covalency = 5 stab by delocalisation through non-adjacent π/σ bond ≡ Carbonium (vs Carbenium) ion)
  → Highly stab in bicyclo systems. ⇒ no e⁻ deficiency
- Racemisation b/c planar [ ✓ ✗ racemisation at 60°C in CH_2Cl_2 b/c F poor LG – no $C^{\oplus}$ formed]
- Stab ∝ (+I) ∝ (HC)

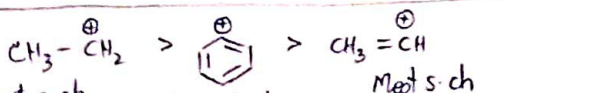
  Strength: +I < HC < +M

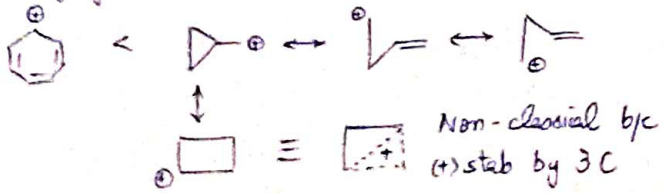
  
  3H 1D > 2H 2D
- When HC > 4 + (#M) → HC dominates
- $^{\oplus}CF_3 > {}^{\oplus}CH_3 > {}^{\oplus}CCl_3$ ⟹ 3p–2p not effective (−I) > (+M)

  ⇓ pπ–pπ back bonding (+M) > (−I)
- 
  9HC > 4M > 8HC

  
  7HC > 2M
- Do not consider HC in cases which involve M
- Aromaticity gain is more stable than $C^{\oplus}$ stab. by disturbing existing aromaticity

  
  Arom gain by $C^{\oplus}$ formation ← 7M > $Ph_3C^{\oplus}$ 10M → Arom of 3 Ph disturbed after $C^{\oplus}$ formation
- s character ∝ EN of C ∝ $\frac{1}{C^{\oplus}\text{ stabilization}}$

  
  $CH_3-\overset{\oplus}{C}H_2$ (Least s.ch) > (less s.ch due to delocalisation) > $CH_3=\overset{\oplus}{C}H$ (Most s.ch)
- Resonance through bent orbital relieves strain and gives highly stab $C^{\oplus}$

  
  Non-classical b/c (+) stab by 3C
- Factors restricting planarity restrict $C^{\oplus}$ formation.

  Eg: BRIDGE HEAD 

→ FORMATION (always in polar protic/aprotic, not in non-polar or gas phase)

① Direct ionisation in polar medium – T depends on LG Tendency

	RI	RBr	RCl
	25°C	60°C	100°C

→ Exceptionally good e.g. → ^{-}OTs Tosyl, ^{-}OTf Triflate

② Acid catalysed ionisation of polar strong covalent bond – use protonic / Lewis acid.

H_3PO_4, H_2SO_4 $ZnCl_2$ $AlCl_3$.

→ Can be also used for multiple bonds C=C C=O

③ Deamination of 1° amine

$R-NH_2 \xrightarrow[0-5^{\circ}C]{NaNO_2\ HCl} R^{\oplus}\ Cl^{\ominus} + N_2 + H_2O$

$NaNO_2 + HCl \rightarrow HNO_2 \xrightarrow[-H_2O]{H^+} NO^{\oplus} + RNH_2 \rightarrow\rightarrow\rightarrow R-N_2^{\oplus}$

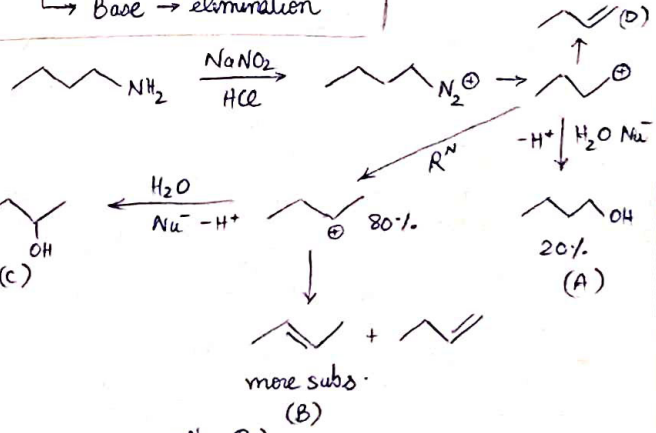
→ REACTIONS

① Nu⁻ subs. (1°)

② β-elimination (3°)

③ R^N → To achieve more stable $C^{\oplus}$.

But 2° → Nu⁻ → subs; → Base → elimination

e.g. 

- C, B > A, D (R^N $C^{\oplus}$)

  C > B > A, D (H_2O = Nu⁻, not Base)

  C > B > A > D (" " " ")

(II) CARBANION

- Trivalent -vely charged C
- sp^3  pyramidal vs sp^2  planar

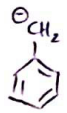
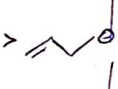
⇓ usually when in conj

① Back bonding $^{\ominus}CCl_3$
② Aromatic
③ Bulky subs → planarity.

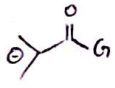
- **FORMATION**

① Never in polar protic b/c all $C^{\ominus}$ strong bases
② By heterolytic cleavage of C bonded w another lg. st. lg departs w/o lp [but this is NP b/c EN of C = 2.4 , F = 4.1, O = 3.8 , Cl = 3 , Br = 2.8 , I = 2.6, only H = 2.1 but C-H bond v. strong !]
③ To generate $C^{\ominus}$, we need acidic $H^{\oplus}$ st. $C^{\ominus}$ is stab by EWG , and EWG has already sufficiently weakened C-H bond as well.
④ Common bases to abstract H → OH^- (moderate); $RO^{\ominus}$ (strong) ; LDA, BuLi, PhLi (strong)

- **STABILITY**

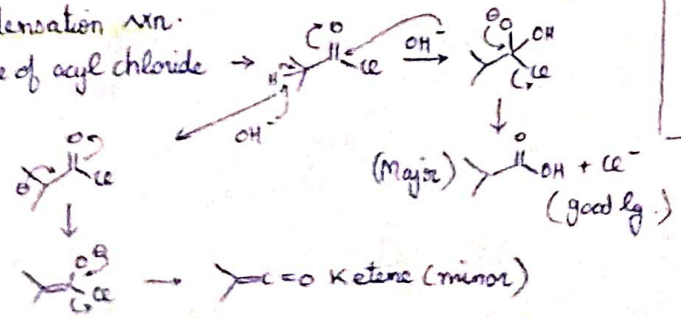
→ $^{\ominus}CH_2-N(=O)=O$ > $^{\ominus}CH_2-C\equiv N$ >  >  > 

-ve charge on O (most EN) | -ve on N (more EN) | 2M | 4M (-M) | 2M (-M)

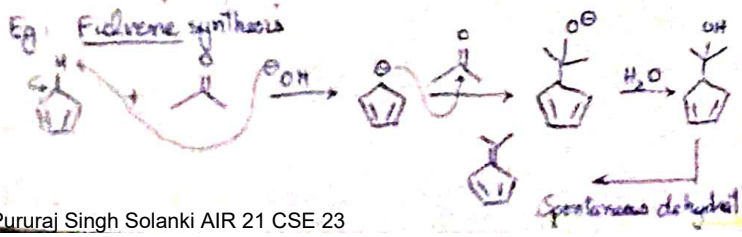
→ CROSS CONJUGATION ($\propto \frac{1}{C^{\ominus}\text{ stability}}$) (depending on nature of G) 

$C^{\ominus}$ stab follows :- G = Cl > H > R > $O^{\ominus}$ > $O^{\ominus}-R$ > OH > OR > NH_2 > NHR > NR_2

b/c NR_2 has max cross conjugation tendency . Cl has (-I) > (+M) ∴ min " " " . Interestingly both amide and acyl chloride do not undergo condensation rxn.

- Case of acyl chloride → 

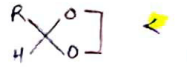
→ Aromaticity achievement stab $C^{\ominus}$

Eg Fulvene synthesis 

→ Back bonding (b/w 2p and 3d)

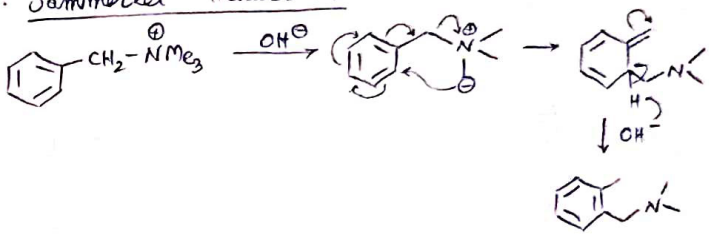
- $^{\ominus}CCl_3 > ^{\ominus}CF_3$; $^{\ominus}CH_2-SiR_3 > ^{\ominus}CH_2-CR_3$
- $> ^{\ominus}CBr_3 > ^{\ominus}CI_3$ (based on EN)

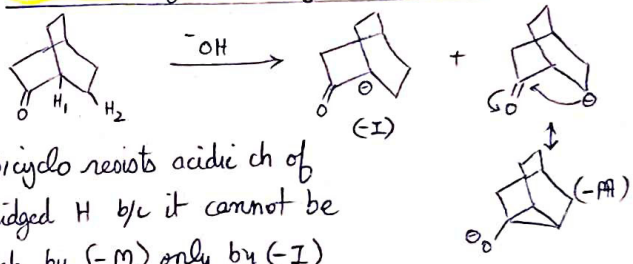
Thus **back bonding > EN**

-  acidity

→ S-ch ∝ stability

→ Field effect (opp. charge on adjacent atom stab -ve by electrostatic F of attraction). It can provide alternate path of stability & is as strong as mesomeric.

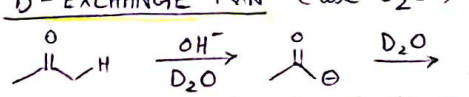
e.g. Sommerlet - Hauser R^N 

→ Resonance of non-adjacent π-bond 

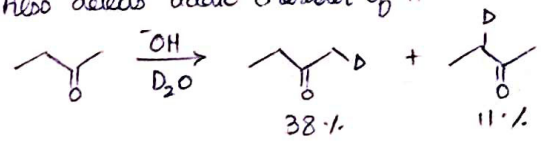
* Bicyclo resists acidic ch of bridged H b/c it cannot be stab by (-M) only by (-I)

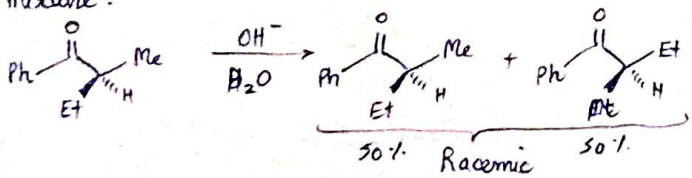
- **DETECTION**

① D-EXCHANGE RXN (use D_2O)

→ 

Detects if Carbanion is actually formed as intermediate

→ Also detects acidic character of H. 

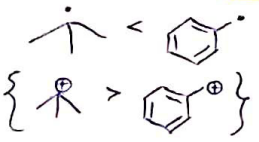
② Optically active compound w acidic H at chiral centre can form $C^{\ominus}$, and in absence of any E^+, can back extract proton from solvent , giving a racemic mixture. 

(III) FREE RADICAL

- Trivalent paramagnetic neutral carbon
- sp^3 pyramidal  or sp^2 planar 
  - Bulky subs repulsion
  - Conjugation
- FR = electrophilic + ↑ Dimerisation tendency.

→ STABILITY

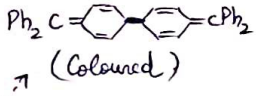
- $\propto (+I) \propto \frac{1}{(-I)}$ based on fulfilling e^- deficiency
- HC = delocalisation of odd e^- ῶ σe^- of C-H bond. Thus it decreases dimerisation tendency.
- Mesomerism → delocalises odd e^- → ↓ dimer^n tendency.
  → NO POLAR EFFECT



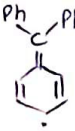
3/4 mesomeric forms cannot dimerise due to complete arom loss ∴ dimer^n tend^y ↓ greatly.

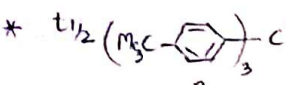
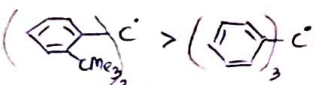
- $Ph_3C^\cdot > Ph_2\dot{C}H > Ph\dot{C}H_2$
  ? b/c ↑ in mesomerism

  mesomerism largely reduced in propellar shape → STERIC HINDERANCE - discourages dimerisation

* $Ph_3CCl \xrightarrow{Ag} Ph_3C^\cdot \xrightarrow{t_{1/2}=24\,hrs}$  (Coloured)

Ph_3C-CPh_3 b/c all bulky (SH)



* $t_{1/2}$  > 

para pos^n blocked

SH → non planar $C^\cdot$ cannot reach para.

- Sch ∝ EN ∝ closeness to nucleus ∝ ↓ e^- affinity
  ∴ $\text{Sch} \propto \frac{1}{C^\cdot \text{ stability}}$

→ FORMATION

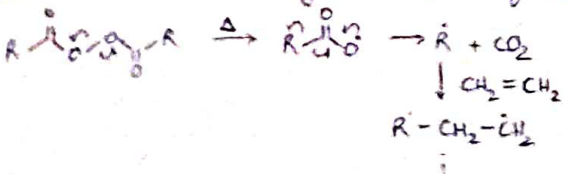
① Thermal decomposn of weak bond (peroxide)

T of rxn $\propto \frac{1}{C^\cdot \text{ stab}} \propto \frac{1}{\text{Elimination of stable molecule } (N_2)}$

($T_{\dot{C}Me_3} < T_{\dot{C}H_3}$ generation)

② Photolysis ($Cl_2 \xrightarrow{h\nu} 2\dot{C}l$)

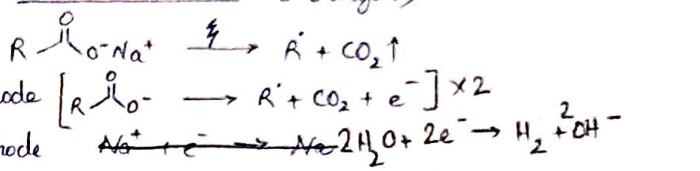
③ Radical initiator – only small amt required.



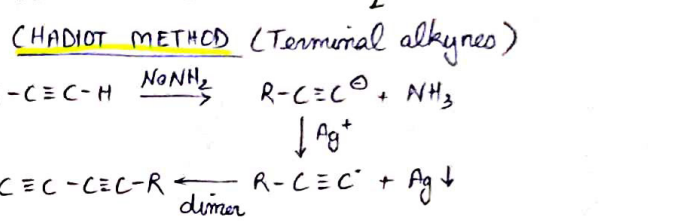
④ Reducing $C^\oplus$ (using Strong RA e.g. $Ti^{3+}(d_1) \downarrow Ti^{4+}$)

⑤ Oxidise $C^\ominus$

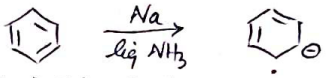
a) KOLBE's METHOD (electrolysis)



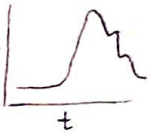
b) CHADIOT METHOD (Terminal alkynes)



⑥ RADICAL ANION (shows prop of FR, not anion)



* Robinwitch effect → explains sudden rise and later stab. of rxn rate involving FR when done in a solvent. FR are trapped initially in solvent cages & later released, ↑ rxn rate



→ REACTIONS

(A) SUBSTITUTION

① FR Halogenation of Alkanes $R-CH_3 + X_2 \xrightarrow{h\nu} RCH_2X + HX$

Initiation $\frac{X_2}{2} \xrightarrow{h\nu} X^\cdot$

Propagation $R-CH_2-H + X^\cdot \longrightarrow R-\dot{C}H_2 + HX$

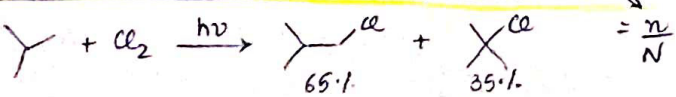
$R-CH_2^\cdot + X_2 \longrightarrow RCH_2-X + X^\cdot$

Termination $R-CH_2^\cdot + R-CH_2^\cdot \longrightarrow R-CH_2-CH_2-R$

$X^\cdot + X^\cdot \longrightarrow X_2$

$R-CH_2^\cdot + X^\cdot \longrightarrow RCH_2X$

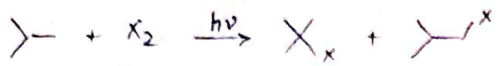
- $F_2 > Cl_2 > Br_2 > I_2$ reactivity
  → Rapid termination – use OA
  $I^\cdot + I^\cdot \xrightarrow{HNO_3} I^\cdot + I^\oplus$
- Alkane reactivity $3^\circ > 2^\circ > 1^\circ >$ Me
- Fraction of any product = (Rate of that rxn centre) × (Statistical factor) $= \frac{n}{N}$

Eg: 

65·1 35·1

$\phi = 0.65 = (P_1)\times(9/10) \rightarrow P_{1^\circ} = 0.7$ similarly $P_{3^\circ} = 3.5$

Hence 3° is 5 times more reactive than 1°, but in this case statistical factor (9 vs 1) is in favor of 1° ∴ major product is 1°.

•  $h\nu$

Cl	35	65
Br	52	48
F	(13)	(87)

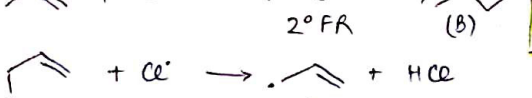
F is so reactive that p becomes unimportant, now only statistics matters, not selectivity.

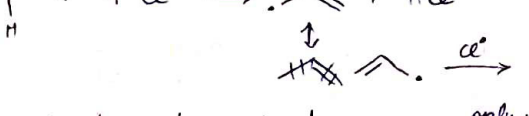
Attack on particular centre when >1 centres present.

∴ Reactivity ∝ $\frac{1}{\text{Selectivity}}$

• At elevated T, Cl becomes as reactive as F and follows

② Allylic Substitution $Cl_2 \xrightarrow{h\nu} 2Cl^\cdot$

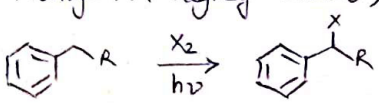
(i) 

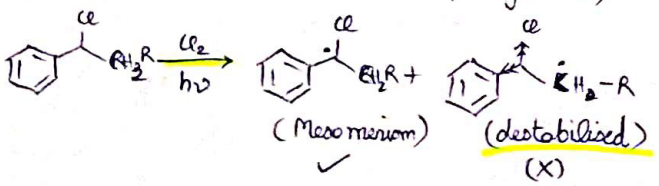
(ii) 

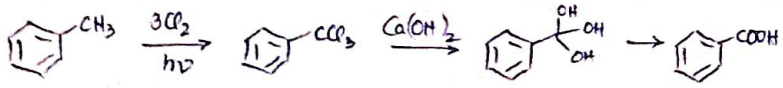
(i) - break weaker π bond → (B) only ~~major~~ at low T (25°C)

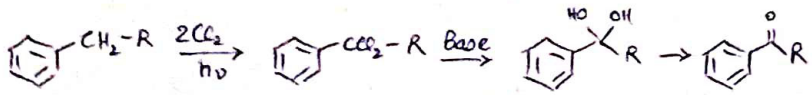
(ii) - break stronger C-H bond BUT form more stable allylic FR (AFR) → possible at high T → (A) major at 100°C (B) minor but always formed (Addition product)

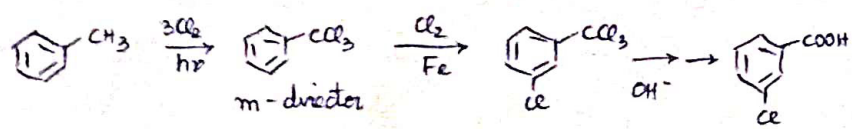
③ Benzylic substitution (always benzyl C· formed, Phenyl FR highly unstab).

•  (show mech, discard phenyl FR)

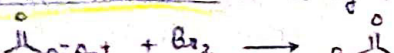


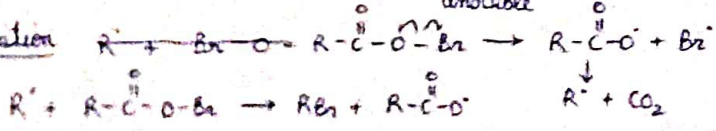
• 

• 

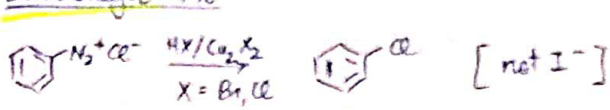
• 

④ Hunsdicker Borodene Rxn $R\text{-}COO^-Ag^+ + Br_2 \xrightarrow{CCl_4} RBr + AgBr + CO_2\uparrow$

Initiation 

Propagation 

⑤ Sandemeyer Rxn



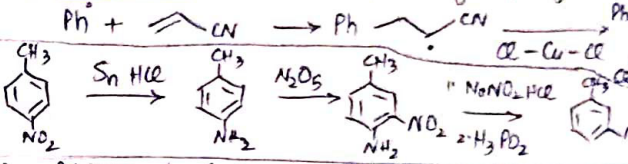
$PhN_2^+Cl^- + CuCl \longrightarrow Ph^\oplus + N_2 + CuCl_2^-$

$Ph^\oplus + \overset{+1}{Cu}Cl_2^- \longrightarrow Ph^\cdot + \overset{+2}{Cu}Cl_2$

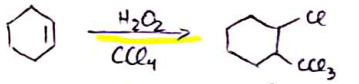
$Ph^\cdot + Cl\text{-}\overset{+2}{Cu}\text{-}Cl \longrightarrow PhCl + CuCl$

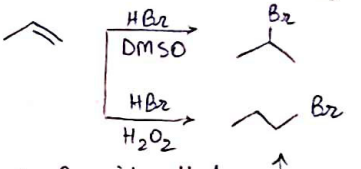
{ But $2Cu_2I_2 \longrightarrow 2CuI_2 + I_2$ not CuI }

• If acetonitrile added last step changes b/c faster

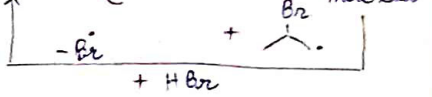


(B) ADDITION (low T, all aliphatic)

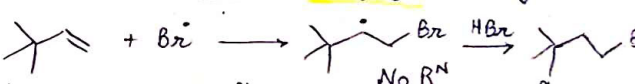
•  (show mech)

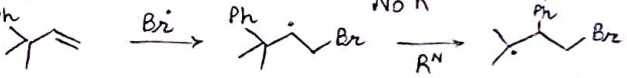
• 

This is Peroxide effect (only HBr)

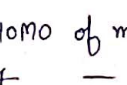


(C) REARRANGEMENT (only few C· migrations known)

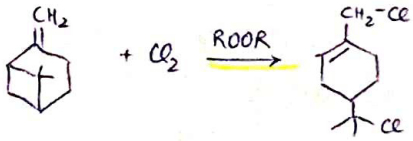
• 

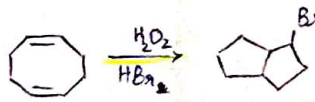
• 

HOMO of migrating subs & LUMO of FR interact.



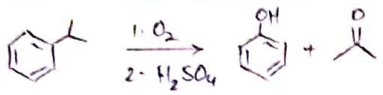
In this case Ph migration is stabilised by mesomeric delocalisation.

•  Relief in strain

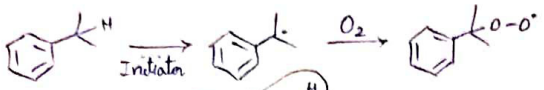
•  Ring contraction

(D) FR OXIDATION

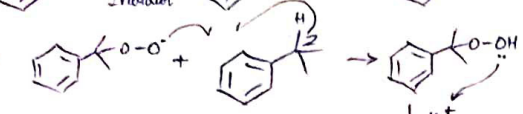
① Cumene Phenol Process

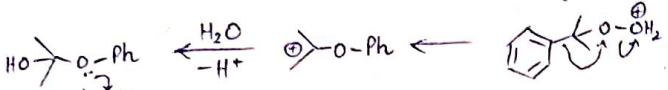


Initiation

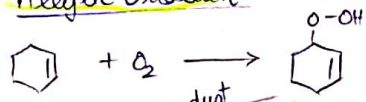


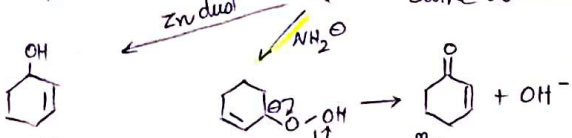
Propagation

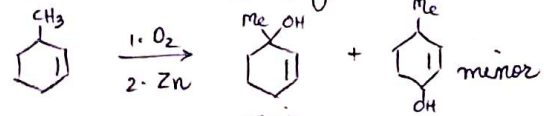


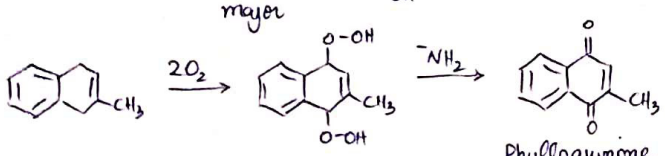


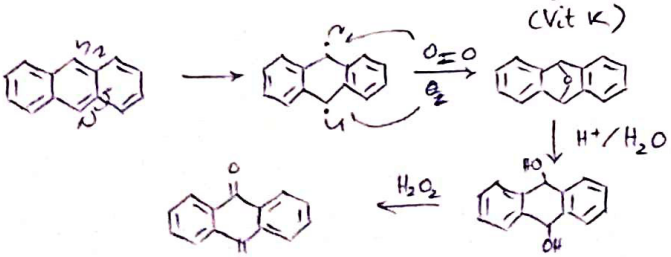
② Allylic Oxidation

-  allylic peroxide (mech same as above)

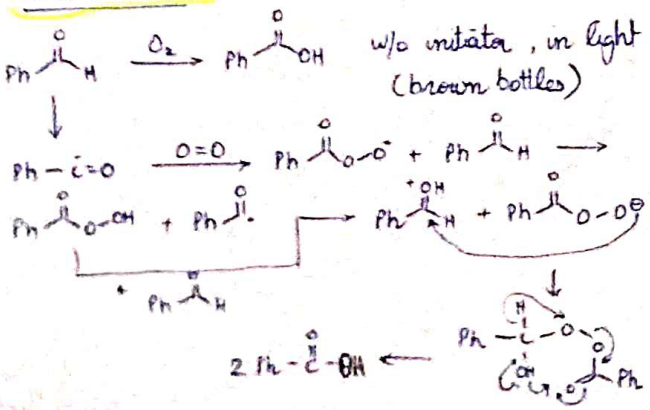


- 

- 

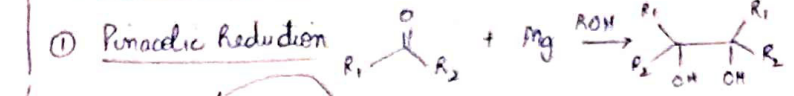
- 

③ Auto Oxidation

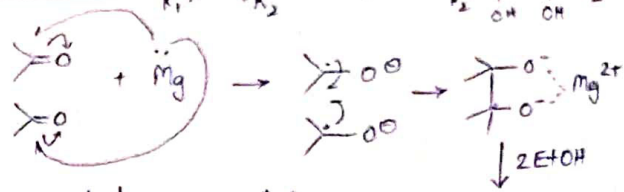


(E) FR REDUCTION { Radical anion intermediate }

① Pinacolic Reduction

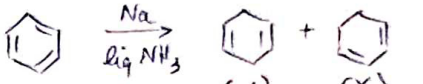


Step-1



* Cross over products are possible if >1 carbonyl taken.

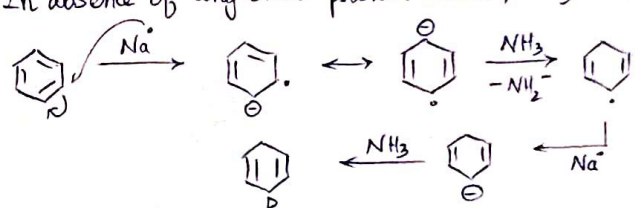
② Birch Reduction

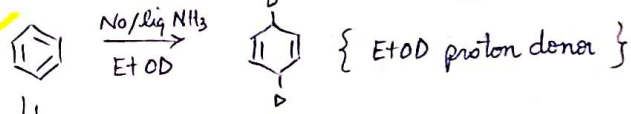


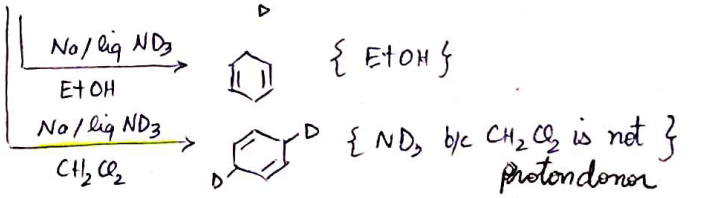
- Alkali metals form blue paramagnetic solution with NH_3.

$M(s) + (x+y)NH_3 \rightarrow [M(NH_3)_x]^+ + [e(NH_3)_y]^-$

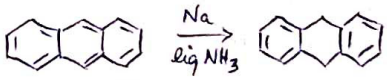
- In absence of any other proton donor, NH_3 does.

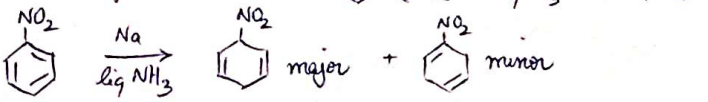


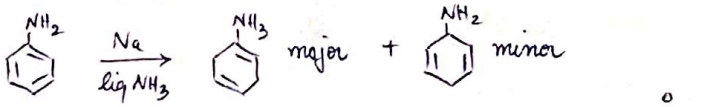


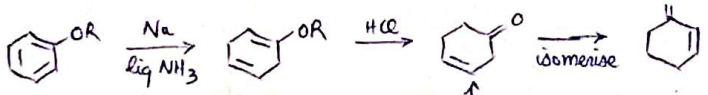


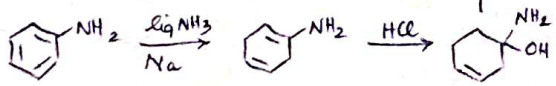
- Aromaticity is retained.



- 

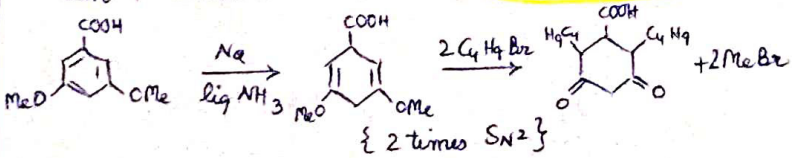
- 

- 

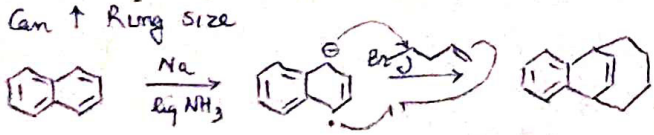
- 

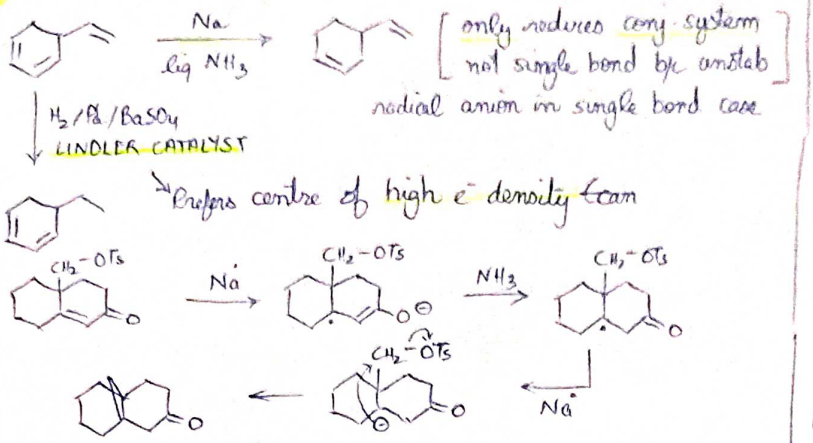
[AROMATIC converted to NON-AROMATIC]

- Can ↑ Carbon chain [MIND – Rxn as per EWG]

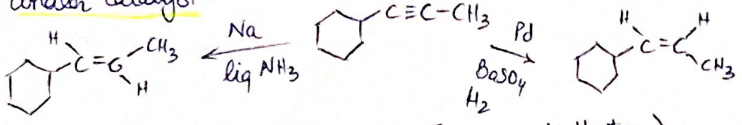


- Can ↑ Ring size

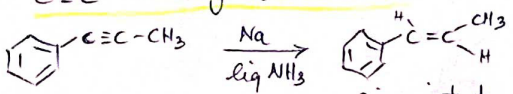




- Triple Bond shows stereospecificity in both Na/NH_3 & Lindlar Catalyst.

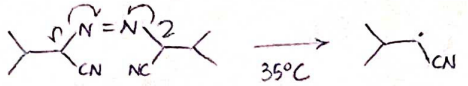


* Relative birch reduction tendency
  → C≡C > conj DB > aromatic.



(F) FREE RADICAL POLYMERISATION

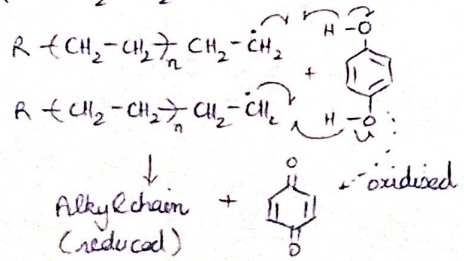
① Initiation (use di-azo compound - cleanest, no explosion as in ROOR, no acidic CO_2 release as in RCOOOOCR)



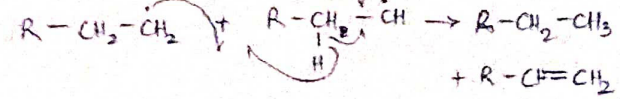
Azo isobutyl nitrile

② Propogation $R^{\cdot} + CH_2=CH_2 \longrightarrow R-CH_2-\dot{C}H_2 \cdots$

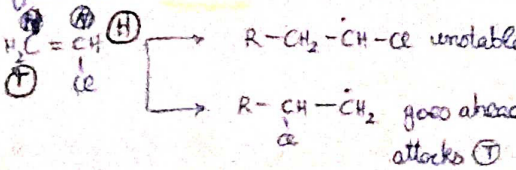
③ Termination



- Combination of alkyl chains may occur at high P
- Chain Transfer Rxn results in unsaturation



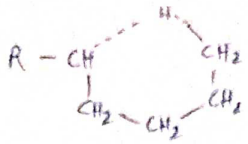
* While generation, only most stable FR takes polymerisation forward. [HTHT or THTH, not HH or TT]

Eg: 

→ Limitations of FR mech

① S H abstraction gives branched polymer

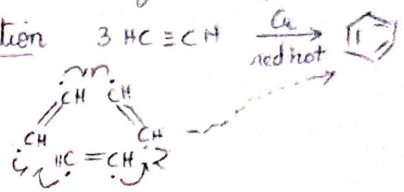
② This is favoured b/c of formation of 6m TS. Process is called BACK BITING (to produce LDPE but LDPE cannot be moulded).



(G) COUPLING

① Chadiot method (see C· formation)

② Benzene production $3\,HC\equiv CH \xrightarrow[\text{red hot}]{Cu}$



Cis → epoxide → Wittig (add PPh_3) → Trans.

(IV) CARBENE

- Highly unstab, only < 78 K, cannot be stored ∴ always generated in-situ
- Singlet vs Triplet

Singlet: sp^2, less reactive, less thermo stab.

Triplet: sp^2 / sp, More reactive b/c behaves like FR, More thermo stab (Hund Rule)

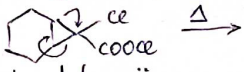
→ GENERATION

① Solution-phase (always singlet carbene)

a) α-α elimination $H-CCl_3 + OH^- \rightarrow {}^-CCl_3 \xrightarrow{-Cl^-} :CCl_2 + Cl^-$

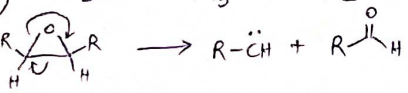
b) Dehalogenation using Metal $Ph-CCl_2-CH_3 \xrightarrow[ether]{2Li} Ph-\ddot{C}-CH_3 + 2LiCl$

② Gas-phase [low T → singlet, high T → triplet]

a) Unstable 3m ring  Ineffective b/c 3m produced by C̈

b) Release of stable molecule $R_2C=N=N \xrightarrow[h\nu]{\Delta} R_2\ddot{C} + N_2$

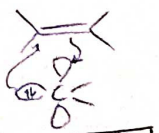
c) Heating Ylides $Ph_3\overset{+}{P}-\overset{\ominus}{C}R_1R_2 \rightarrow Ph_3P + \ddot{C}R_1R_2$

d) Epoxide decomposition 

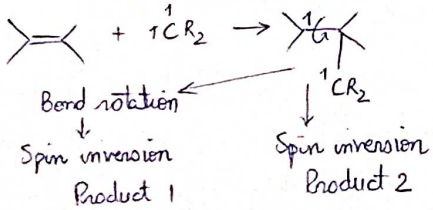
→ REACTIONS

(A) ADDITION – gives cyclopropane derivative.

- Singlet undergoes stereospecific add^n, but not triplet.



CONCERTED MECH



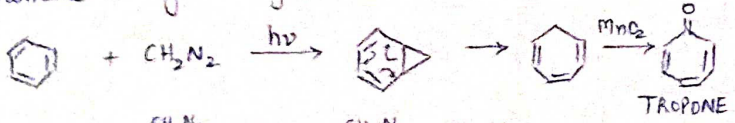
Bond rotation → Spin inversion → Product 1

Spin inversion → Product 2

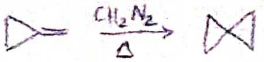
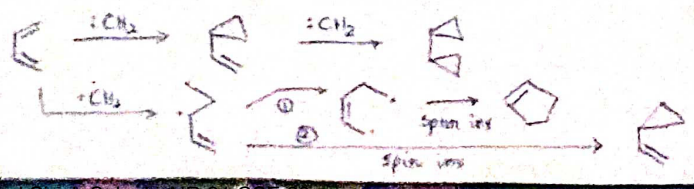
- Bulkier group leads to slower bond rotation and lesser fraction of trans product.

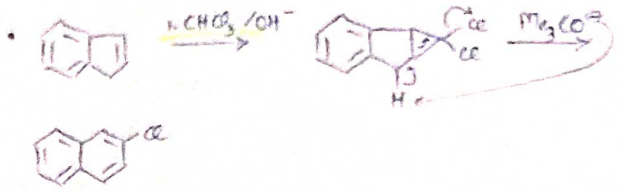
R = Ph	82%	18%
R = CH_3	68%	32%

- Aromatic undergoes only photochem add^n, not thermal.

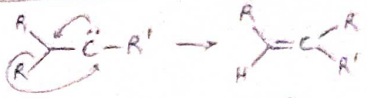


TROPONE

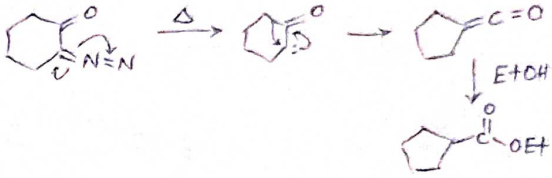
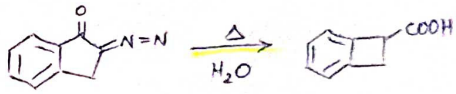
- $CH_2=C=CH_2 \xrightarrow[\Delta]{CH_2N_2}$ 
- 



(B) REARRANGEMENT

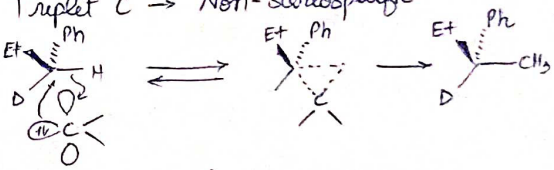
① Alkyl R^N 

② Wolff Rearrangement (gives Ketene)

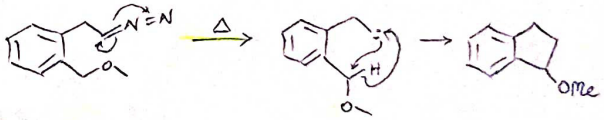
- 
- 

(C) INSERTION (when no add^n / R^N possible)

- Singlet C̈ → single step insertion – stereospecific
- Triplet C̈ → Non-stereospecific



- Intramolecular insertion



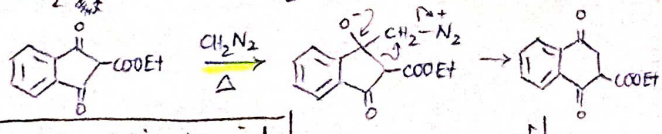
(D) DIMERISATION (all others absent then only)

⇒ CARBENOID – No evidence of Carbene and intermediate is neutral (so no $C^\oplus$ / $C^\ominus$)

e.g. a) Zinc Carbenoid $CH_2I_2 + Zn \rightarrow I-CH_2-ZnI$ SIMON SMITH REAGENT

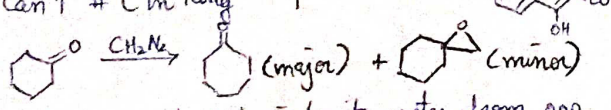
CH_2 acts as Nu^- un like Carbene (E^+)

b) $CH_2=\overset{+}{N}=\overset{-}{N} \rightarrow \ddot{C}H_2-N\equiv N$ in solution phase.

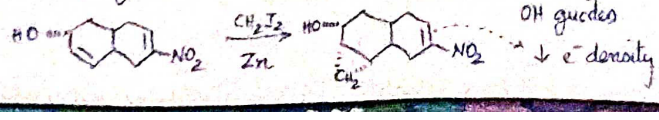
- 

* Smaller substituent migrates | (Gain of Arom)

* Can ↑ # C in Ring



- Attack occurs at high e$^-$ density centre from opp. side of bulky subs. If polar group present, it guides attack from the side on which it is present.



OH guides ↓ e$^-$ density

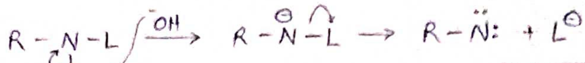
(V) NITRENE

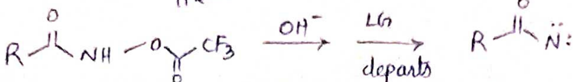
- Analogue of Carbene = monovalent N.
- Less stab than carbene, all rxns v. similar to it.

R – N̈ ⇅ Singlet   R – N̈ ↑ Triplet

→ **GENERATION**

① Solution phase





* LG must be good b/c N̈: already v. unstable.

② Redox reaction (only singlet)

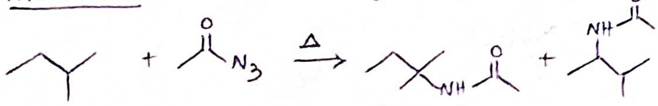
- $\overset{+3}{R-NO_2} + 2Mg \xrightarrow{H^+} \overset{-1}{R-\ddot{N}:}$ (4e⁻ process)
- $\underset{+1}{R-NO} + Mg$ (or $P(OEt)_3$) $\xrightarrow{H^+} \underset{-1}{R-\ddot{N}:}$ (2e⁻ process) $+ Mg^{2+} / PO(OEt)_3$

③ Gas Phase – azide decomposition (convenient)

$R-N=\overset{\oplus}{N}=N^{\ominus} \xrightarrow{\Delta} R-\ddot{N}: + N_2\uparrow$

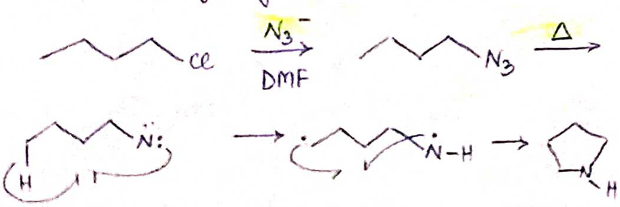
→ **REACTIONS**

① INSERTION (mech same for singlet / triplet)

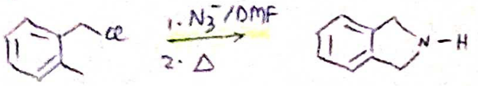
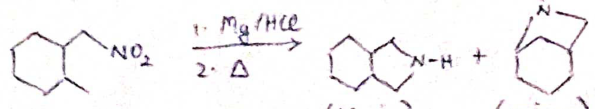


(Major)
3° FR stable.

* Intramolecular insertion of N̈: occurs via δ – H abstraction, giving pyrallodine derivative.



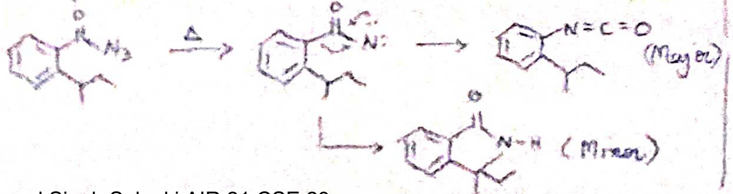
If >1 δH, decide major on FR stability.

- 
- 

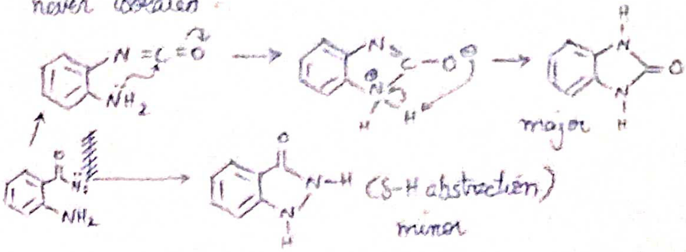
(Major)   (minor)

② REARRANGEMENT

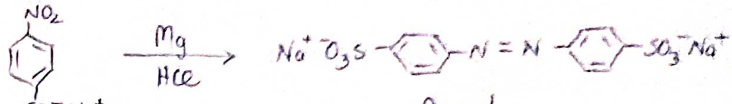
- Acyl nitrene after Rᴺ gives isocyanate (Curtius / Schmidt / Lossen)
- Always competes w abstraction but Rᴺ always major pdt



- If Nu substituent at ortho, isocyanate is never isolated.

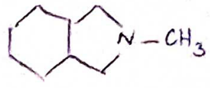


③ DIMERISATION (forms azo compounds)



Azo dye

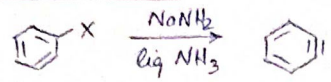
④ ADDITION (3m ring, unimportant)

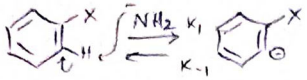
⇒ ① Sn/HCl
② CH_3I
③ HLF rxn (hν)
} for 

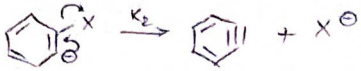
(VI) BENZYNE [ORTHO H necessary]

- Benzene ῶ extra π bond, de-polar structure too,
- HIGHLY SPECIFIC (both E^+ & Nu^- attack)
- less aromatic than benzene, reactive b/c internal overlap of extra π is SH.

→ **GENERATION**

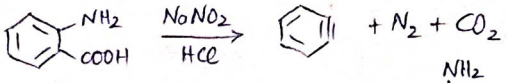
① 

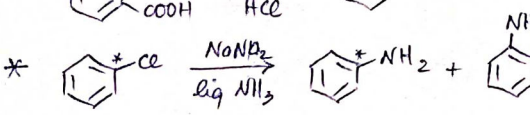
Step 1  ORTHO elimination

Step 2 

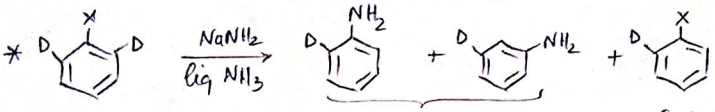
- $K_2 \gg K_{-1}$ for Cl, Br, I
- $K_2 \ll K_{-1}$ for F → does not produce Benzyne ῶ $NaNH_2$ ∴ we use BuLi → LiF stronger bond compared to C-F.

② Chelotropic Method → Peak @ 76 in Mass spectro (Dipolar st.)

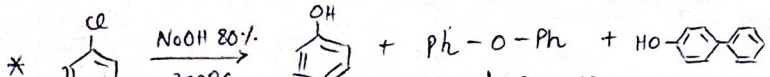


*  evidence for benzyne mech.

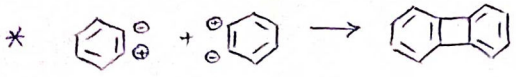
(ELIMINATION - ADDITION)

* 

X = ClBrI	90-95 %		5-10 %
X = F	2-3 %		97-98 %

* 

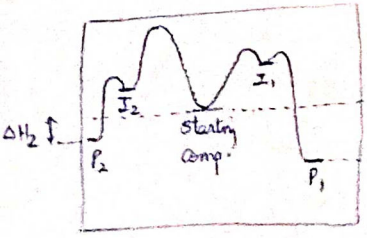
DOW's PROCESS

* 

TCP vs KCP

KCP = Lower Ea ∴ Lower T mostly

TCP = Lower H value - mostly higher T

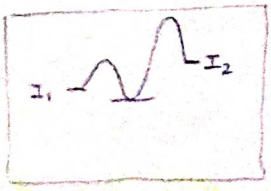


I_2 = TCP I_1 = KCP

P_2 = KCP P_1 = TCP

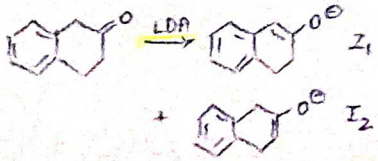
I = intermediate

P = product



I_1 = KCP ∴ I_2 not formed

I_1 = TCP

e.g. 

NUCLEOPHILIC SUBSTITUTION

→ Nucleophile donates ep to form covalent bond to either polarised or +ve ch. carbon. It is a Kinetic concept - depends on many factors

→ Base = ep donation to p^+ = Thermo concept

$B + H^+ \rightleftharpoons [B-H]^+$

$K_b = \frac{[BH]^+}{[B][H^+]}$ $\quad \Delta G = -RT\ln K_b$

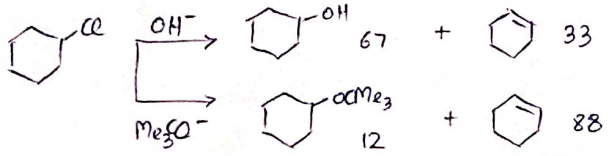
If $[BH]^+$ ↑, ΔG more -ve

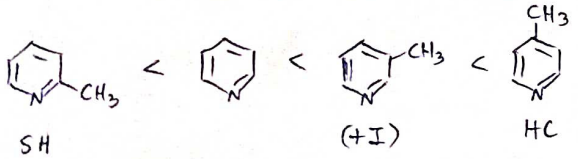
→ Nucleophilicity affected by: ∝ -ve ch. on species ∝ $+I \propto \frac{1}{(-I),(-M)}$ ∝ Polarisability (↑ from R to L, ↑ from top to bottom)

* Nucleophilicity ∝ $\frac{1}{SH}$ even though a bulky Nu^- may be a very potent base.

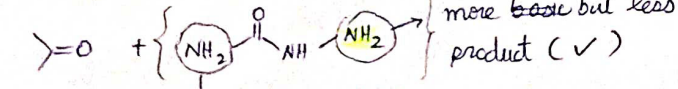
Base: $NH_3 < Me-NH_2 < (Me)_2-NH < (Me_3)N$

Nu^-: ≥ > >

- 

- 

- $^{\ominus}O-OH >> \bar{O}H$ b/c of push (by lp of O) and pull (by incoming E^+ centre).

- 

will form more stable pdt (✗) but v. less Nu^-

∴ $>=O + \{\ \} \rightarrow >=N-NH-\overset{O}{\overset{\|}{C}}-NH_2$

- Solvent Role: $I^- > Br^- > Cl^- > F^-$ polar protic → ↑ solvation ↓ charge density

BUT $I^- < Br^- < Cl^- < F^-$ in p.aprotic, gas → ↓ ch-density.

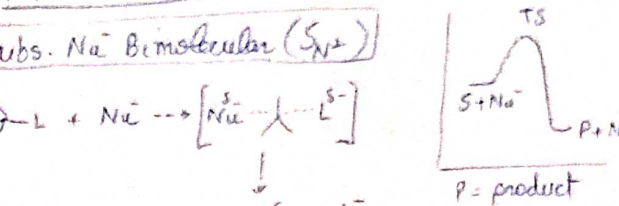
- Cation Role: Larger cation better stab by larger anion. So if attached to anion of suitable size, Nu^- is delayed.

- Macrocyclic ether: Promotes Nu^- exceptionally by accomodating its cation in its cavity thus releasing Nu^- early.

Cl^- free early → better Nu^- b/c drag force of counter ion minimised.

⇒ MECHANISMS

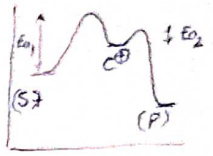
① Subs. Nu^- Bimolecular (S_N2)



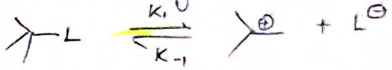
Nu^- adds ep in σ^* of C-L σ, breaks it & forms a new σ

Rate = K_2 [substrate] [Nu^-] (S)

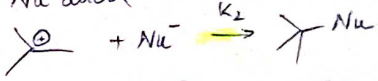
② S_N1



Step-1 Ionisation to give $C^{\oplus}$



Step-2 Nu^- attack



Applying SSA on $>^{\oplus}$ ⇒ $[R^{\oplus}] = \frac{K_1[R-L]}{K_{-1}[L^{\ominus}] + K_2[Nu^-]}$

∴ $\frac{d[P]}{dt} = \frac{K_1 K_2 [R-L][Nu^-]}{K_{-1}[L^{\ominus}] + K_2[Nu^-]}$

- Common ion effect (adding $L^{\ominus}$ strong electrolyte) ↓ rate
- If $C^{\oplus}$ exceptionally stable, $K_2[Nu^-] \sim K_{-1}[L^{\ominus}]$ denominator cannot be neglected ∴ complex kinetics. Since Nu^- is weak in S_N1, stable $C^{\oplus}$ survives its attack by stronger $L^{\ominus}$ can still force Step-1 backward.

⇒ FACTORS AFFECTING S_N2 & S_N1

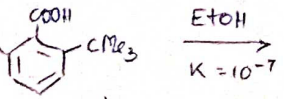
① S character (negatively affects both)

② LG tendency (positively affects both)

③ Electrophilicity of attack site ∝ $S_N2 \propto \frac{1}{S_N1\ (C^{\oplus}\ stab)}$

④ SH ∝ $\frac{1}{S_N2}$ (both SH in substrate & Nu^-)

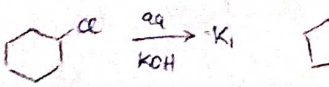
⑤ SH ∝ S_N1 in substrate (steric acceleration)



✗ esterification (SH ↑)

✓ esterification (SH ↓)

vs OTs as eq. (II) (Higher E_a) → $K_I = 21\ K_{II}$ for hydrolysis (S_N1)

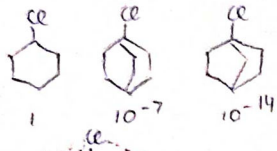
- 

$K_2 = 5\ K_1$

b/c of relief in strain in envelope form, but not in equatorial of chair form when $C^{\oplus}$ forms.

* Combining SH & polar effects gives mechanism borderline

3°	2°, Benzyl, allyl	1°
S_N1	S_N1 / S_N2 (Ligand and solvent dependence)	S_N2
↑ Steric acceleration		↓ SH
↑ # of subs → ↑ $C^{\oplus}$ stab		↑ electrophilic

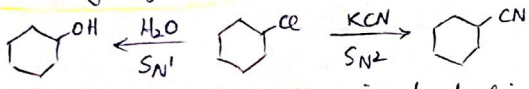
- 

S_N1 rate (↑ # C on bridge head ↑ flexibility)

- 
undergoes S_N1 b/c of ring strain relief

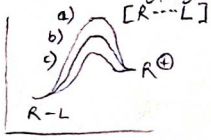
Adamantyl chloride

⑥ If Nu^- attacks before/after LG leaves, then S_N2 / S_N1 occurs. ∴ A stronger Nu^- has more tendency for S_N2.



Nucleophilicity only matters in borderline cases.

⑦ SOLVENT effect →

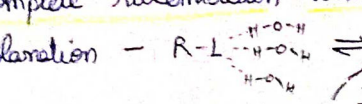
(S_N1) 

On moving from NP(a) → P.Ap(b) → P.P(c) more polar TS is better stab
∴ S_N1 in polar protic

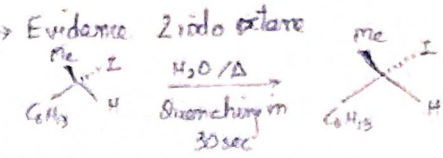
(S_N2) → polar protic never used b/c it solvates Nu^- and hampers attack.
→ When both substrate & Nu^- charged, best choice is non-polar b/c even p.aprotic causes more stab of reactants compared to TS
→ When ~~only one of subs~~ subs neutral & Nu^- negatively charged, can use polar aprotic and non-polar.
→ When subs + ch. & Nu^- neutral, use non-polar.

[Remember p.ap cannot stab -ve but can stab +ve]

* PECULIAR CASE OF S_N1 :

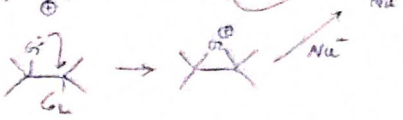
- While S_N2 gives complete inversion, S_N1 always gives incomplete racemisation with some degree of inversion
- Explanation – 

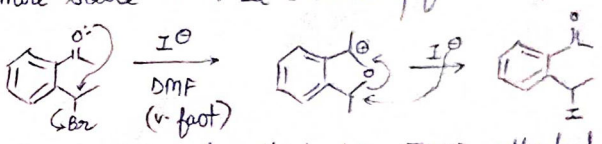
tendency to attack more from back ∴ some inversion always extra than racemisation.
- % Racemisation ∝ $C^{\oplus}$ stability (IIP, SSIP quickly bypassed)
∝ LG tendency (" " ")
∝ Solvent polarity (" " ")

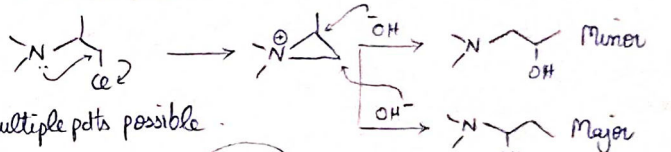
→ Evidence 2-iodo octane 

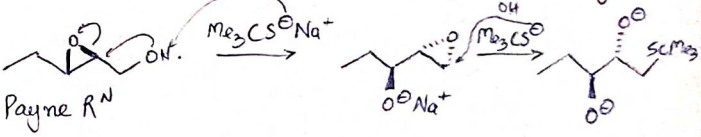
=> NEIGHBOURING GROUP PARTICIPATION
(Rate exceptionally high + complete retention)

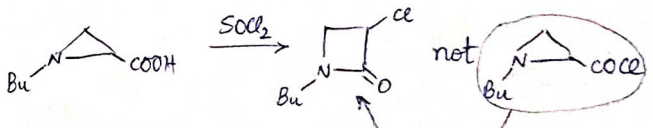
S_N1 like 

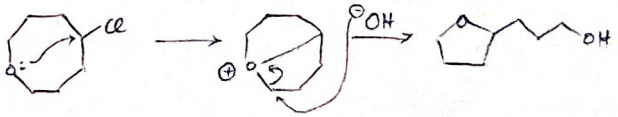
S_N2 like (Anchimeric) 

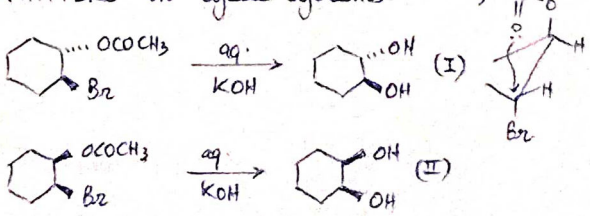
- -OH X NGP
- $\Delta S_{intra\ attack} \sim 0$ (Thermo favoured); Cyclic carbonium ion more stable → ↓ Ea (Kinetically favoured)
- 

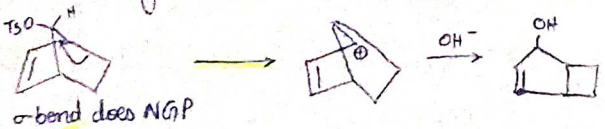
{Ring did not attack b/c EWG attached}
- 

Multiple pdts possible.
- 

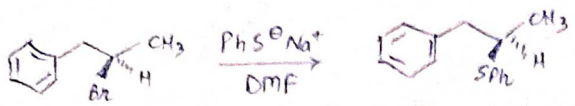
- 

initially forms but converts to 4m ring via NGP.
- 

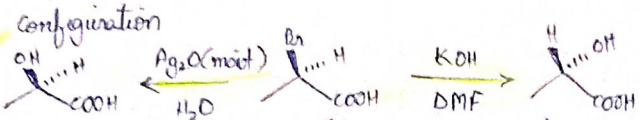
* Anchimeric requires anti-orientation b/w G & L. This MATTERS in cyclic systems.
- 

S_N1 like mech possible in both, but (I) additionally can undergo anchimeric ∴ $K_I = 10^6 K_{II}$
- 

σ-bond does NGP



expected S_N2 but ring does NGP - retention of configuration

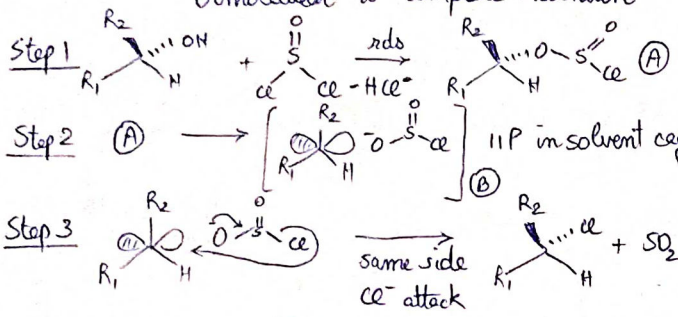


$(COO^- > H_2O\ Nu^-)$ NGP Retention

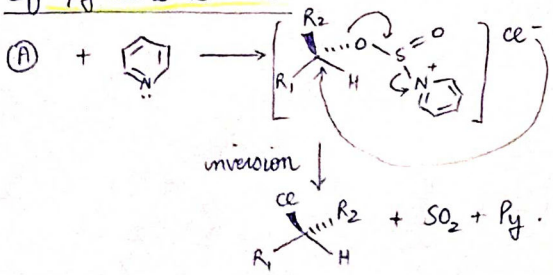
$(OH^- > COO^-\ Nu^-)$ no NGP Inversion

⇒ S_Ni $\quad ROH + SOCl_2 \rightarrow RCl + SO_2 + HCl$

Bimolecular w complete retention



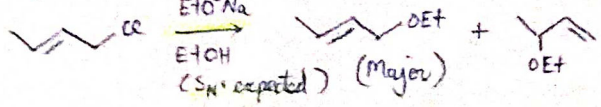
* If pyridine is added.

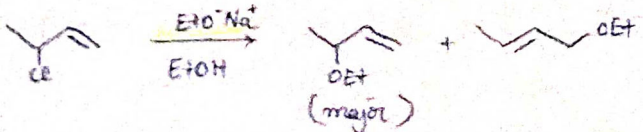


- Retention is property of both $SOCl_2$ & $COCl_2$.

⇒ S_N1' (Prime) [ALLYLIC R^N]

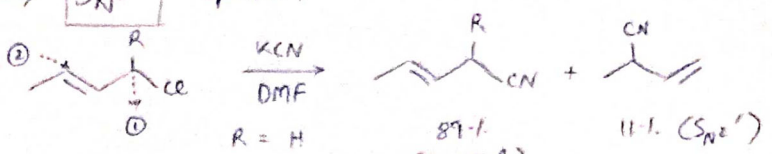
- Product looks similar to starting reactant b/c $C^\oplus$ formation needs time (IIP, SSIP etc.). Till the time $C^\oplus$ is not formed, Nu^- attacks preferably where LG is about to leave & $C^\oplus$ is about to form, rather than where $C^\oplus$ may go after allylic R^N.





- If solvent polarity ↑, IIP, SSIP are quickly bypassed & final product is based on actual $C^\oplus$ stab.

⇒ S_N2' (prime)



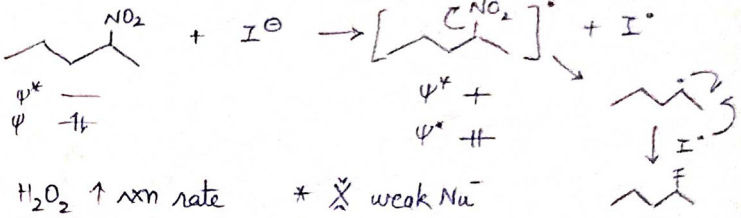
R = H: 89% (normal), 11% (S_N2')

R = C_4H_9: 4%, 96%

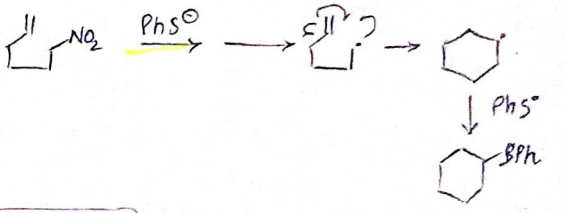
(more SH + less electrophilic ① compared to ②)

⇒ SINGLE ELECTRON TRANSFER

(when poor LG BUT v. good Nu^-)

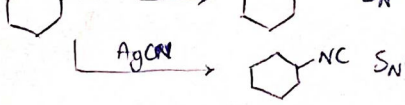


* H_2O_2 ↑ rxn rate * ✗ weak Nu^-
* Independent of solvent.
* R^N possible



⇒ AMBIVALENT LIGANDS

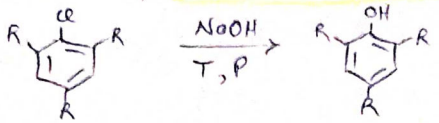
* S_N2 - polarisability matters
* S_N1 - EN atom attacks due to electrostatic attraction.



promoted by Ag^+ → facilitate $C^\oplus$ formation)

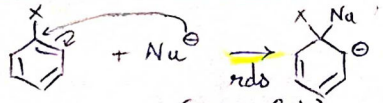
⇒ **Nu^- SUBS ON ARYL HALIDE**

- Not expected b/c Nu^- repelled by e⁻ cloud of benzene, halide already in conjugation, C is sp^2 hyb.
- Even S_N1 produces unstable $C^\oplus$ ($Ph^\oplus$)
- HOWEVER, EWG (like NO_2) does magic!

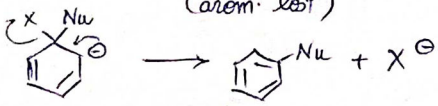


When all R = H → 300°C 350 atm, 6 hrs
1 R = NO_2 → 125°C 50 atm, 4 hrs
3 R = NO_2 → 25°C 5 min (Picric acid) is formed.

* **S_NAr** 2 step bimolecular

Step 1 

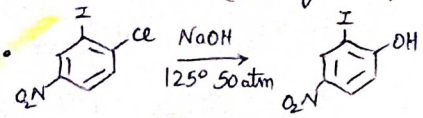
(2 more resonating) (arom. lost)

Step 2 

Rate = $K_2[ArX][Nu^\ominus]$

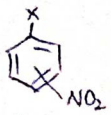
- No effect of LG ∴ Rates of ArI ~ ArBr ~ ArCl

HOWEVER ArCl << ArF b/c most electrophilic 'C' (EN of F = 4)

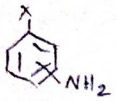
- 

(-M)

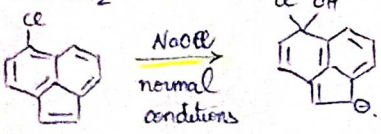
NO_2 already 'activates' ring for Nu^- attack.

- 

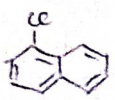
Reactivity order p > o > m
→ most stab. canonical

- 

Reactivity order m > p > o → additionally SH

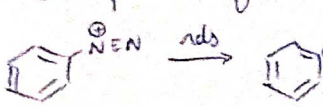
- 

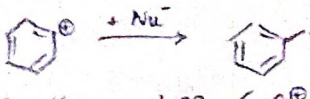
Benzenoid ch of 1 ring maintained → sits here.

However 

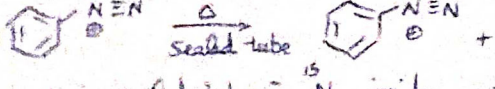
× b/c benzenoid ch of both rings lost.

* **S_N1Ar** Decomposition of diazonium salt

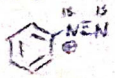
Step 1 

Step 2 

Evidences: • $K_H/K_D = 1.22$ (C⊕ stab by HC)

- 

equal ratio

- If Δ in sealed tube is $^{15}N_2$ inside, entire salt is 

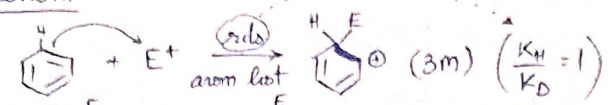
→ Do not confuse with Benzyne mech. That one is highly specific with specific reagent ($NaNH_2$ / liq NH_3)

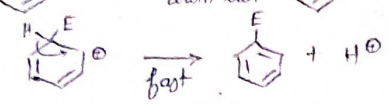
* Note - BIRCH = Na / liq NH_3

ELECTROPHILIC SUBSTITUTION

(specific to aromatic compounds)

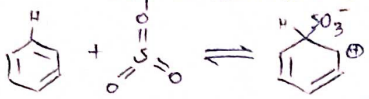
→ Mechanism

Step 1 

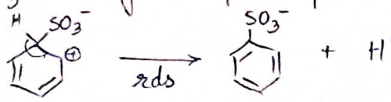
Step 2 

HOWEVER SULFONATION IS REVERSIBLE

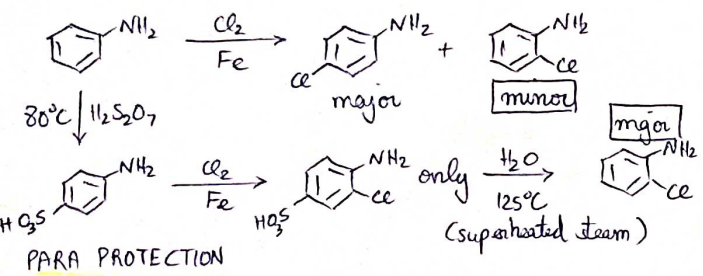
Step-2 becomes rds

Step-1 

SO_3 is bulky & hinders deprotonation ∴ step 1 rev.

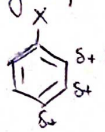
Step-2 

* Using Sulphonation as protecting reagent



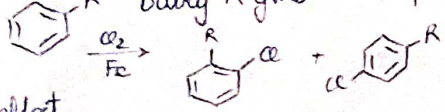
→ Directing Influence of Substituent (G)

- For +M, +I → activates ring → o, p [p > o > m]
- For −M, −I → deactivates → m [m > p > o]
- Special case of halogens, Ph → (−I) > (+M) still they are o, p

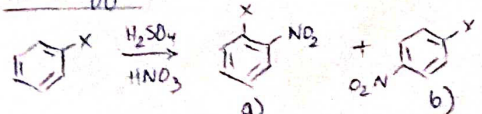


m always has δ+
o, p have lesser δ+ b/c of (−M) influence.

→ o-p Ratio during activated E^+ subs

① SH 

Bulky R gives more para.

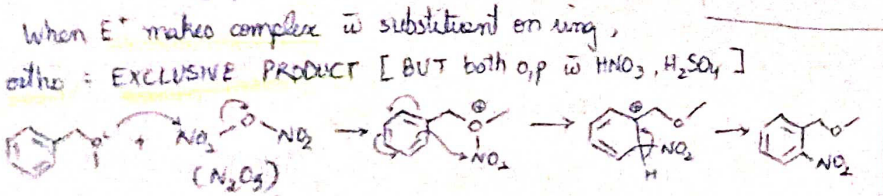
② Polar effect 

a) b)

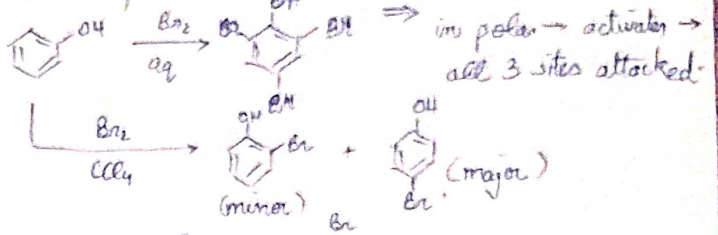
From Cl → Br → I, % a) ↓ b/c of SH

But F has lowest a) % b/c of its high EN, ortho is strongly deactivated.

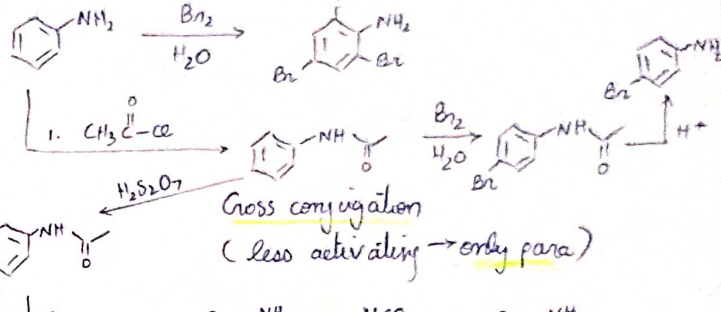
③ When E^+ makes complex w substituent on ring, ortho : EXCLUSIVE PRODUCT [BUT both o, p w HNO_3, H_2SO_4]



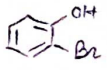
→ Reactivity & Solvent

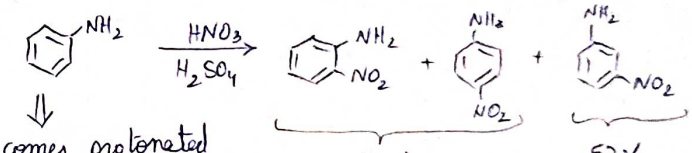
① 

⇒ Phenol exists as PhO^- in polar → activates → all 3 sites attacked.

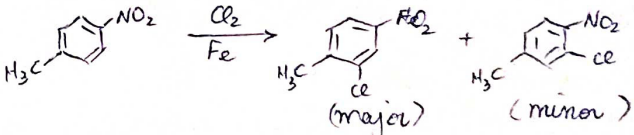
② 

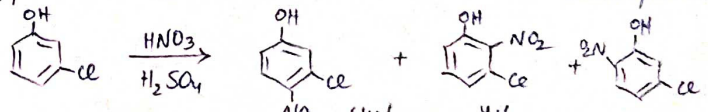
Para protection

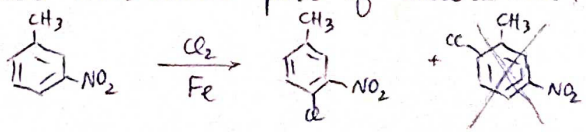
↳ can be used to get  as major.

* 

becomes protonated & m-director in acidic medium.

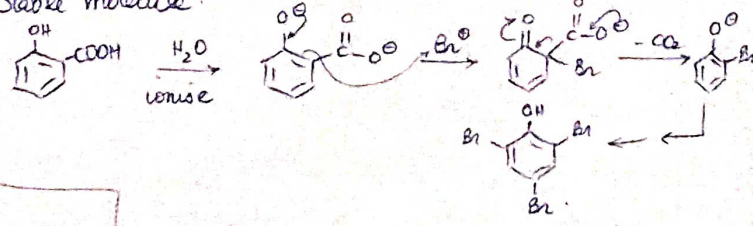
• Subs orientation controlled by more activating substituent 

• o, p directors @ meta will never allow subs b/w them. 

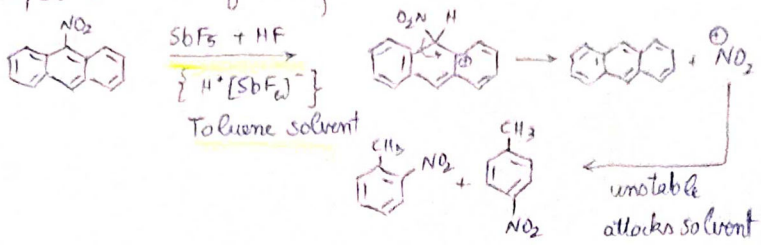
• Subs never attacks para of meta director. 

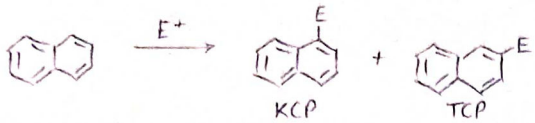
→ IPSO ELECTROPHILIC SUBSTITUTION

• EWG - ERG o/p to each other + EWG removal as a stable molecule.

* 

- Ipso can occur if exiting molecule unstable!

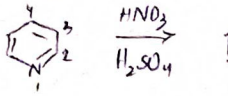


- 

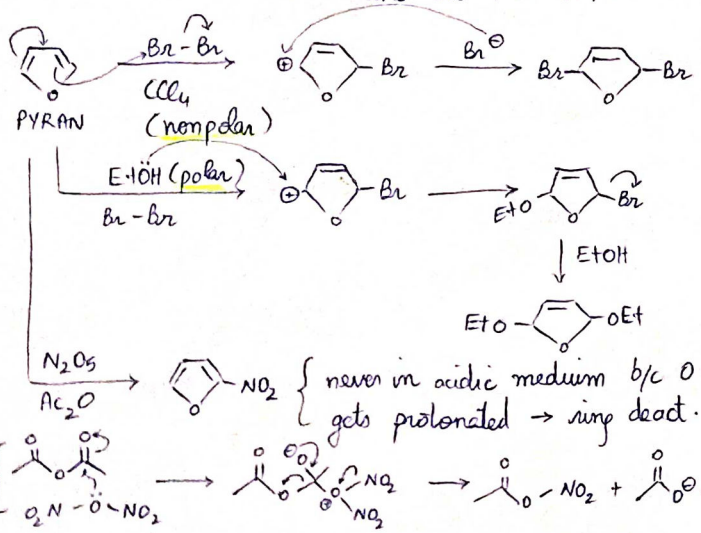
Small $E^+ = CC^+$ 68 % 32 %

Bulky $E^+ = {}^+SO_3H$ @ low T @ high T

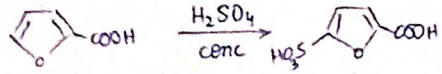
- Pyridine is > deactivated than Nitrobenzene



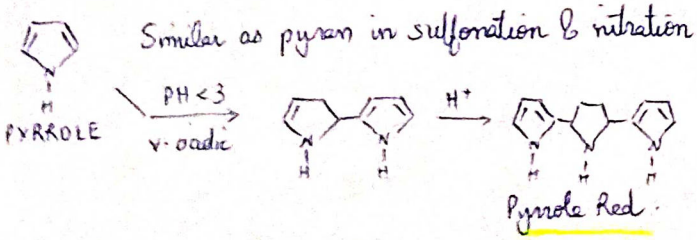
Consider attack on all 1, 2, 3, 4 and see +ve on N.

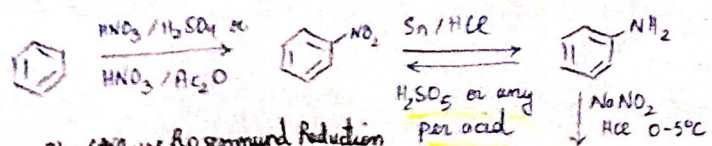
- 

Similarly avoid acidic for Sulfonation (use SO_3 in Py) but if EWG attached, can use acidic.

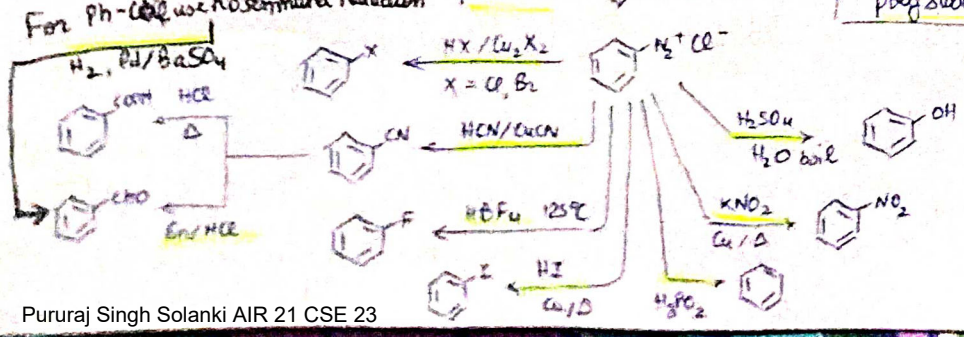


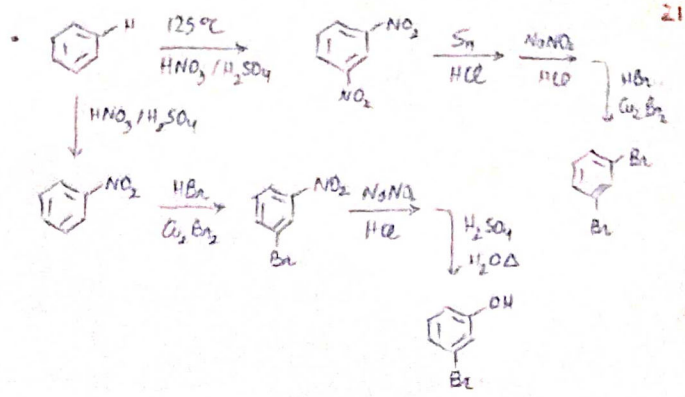
- Similar as pyran in sulfonation & nitration



- 

For Ph-CCl use Rosenmund Reduction

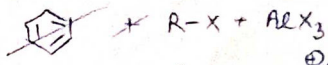


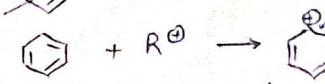


⇒ FRIEDAL CRAFT REACTIONS

(I) ALKYLATION

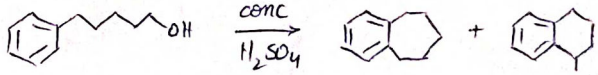
→ Benzene + alkyl halide ῶ LA gives alkyl benzene

Step 1 

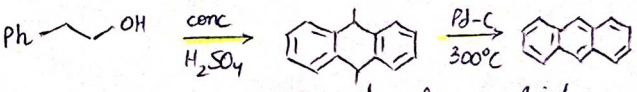
Step 2 

→ In general, any reagent which generates $R^⊕$ can give this rxn. But major problems are $C^⊕$ Rearranged alkyl product and poly substitution on o/p after 1st alkylation.

→ Intramolecular alkylation is much useful. But it preferably gives 5m / 6m rings.



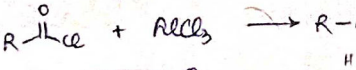
→ When side chain C is less than 3.



∴ FC alkylation is only used for cyclisation followed by aromatisation (Se/Δ)

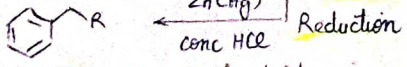
(II) ACYLATION

→ Benzene + acyl chloride in LA gives Acyl benzene.

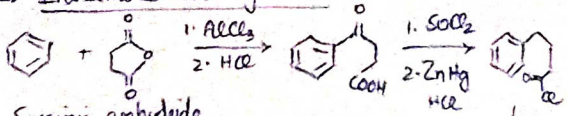
Step 1 

Step 2 

Now all worries about rearrangement in R due to $C^⊕$ are gone! Also since Carbonyl deactivates ring, polysubstitution is absent.



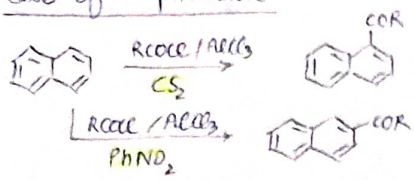
→ Intramolecular acylation



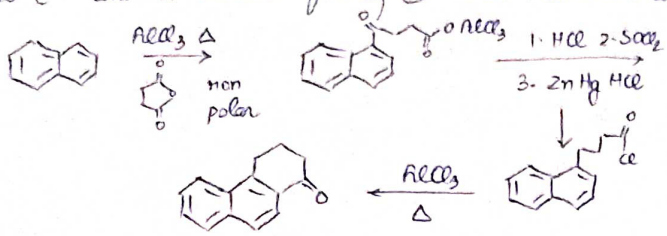
Succinic anhydride

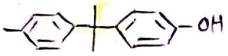
HAWORTH SYNTHESIS

- **Case of Naphthalene**



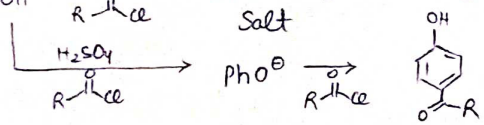
Polar medium solvates & stab $C^{\oplus}$, enhancing its selectivity. But Non-polar medium does not stab $C^{\oplus}$ and it attacks quickly @ more reactive site.



- 2 Ph-OH +  $\xrightarrow{H_2SO_4}$ 

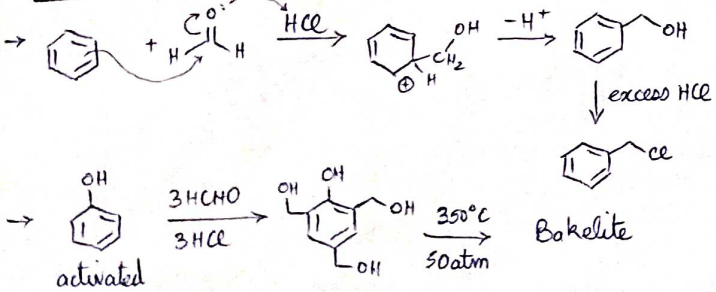
Bisphenol A

- PhÖH $\xrightarrow{AlCl_3}$ Ph O-$AlCl_2$ + HCl (No FC acylation)
  Salt

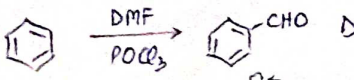


- Ph-NH_2 deactivates in H^+ and forms salt w $AlCl_3$
  ∴ No FC acylation whatsoever

- **LEDRER MANNASE RXN**

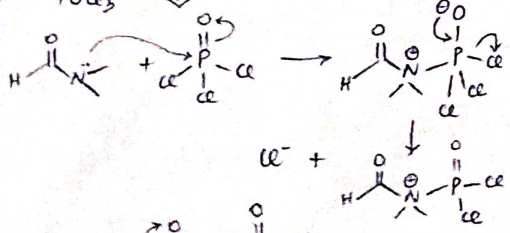


- **VILSMEIER FORMYLATION**

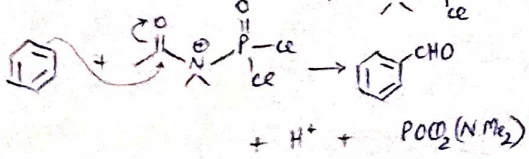


DMF = electrophile!

Step 1



Step 2



+ H^+ + $POCl_2(NMe_2)$

ELIMINATION

E_2 E_1 E_{1cB} E_i

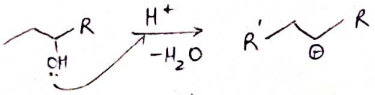
⇒ **E_2** Single step bimolecular – base attacks β-H ῶ simultaneous departure of LG.

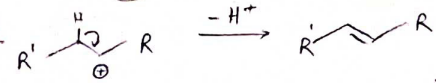
Rate = K_2 [substrate][base]
- depends on both quality & quantity of base.
- strong primary kinetic isotopic effect.

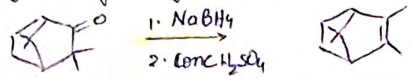
Rate ∝ better LG tendency

- Generally in dehydrohalogenation and dehalogenation.

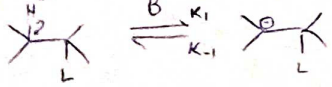
⇒ **E_1** Unimolecular 2 step rxn via $C^{\oplus}$

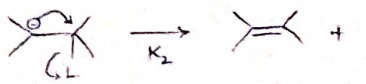
Step 1 

Step 2 

- Use H_2SO_4 and H_3PO_4 b/c their CB is v. less Nu^- Do not use HCl, HBr, HI b/c $Cl^- Br^- I^-$ good Nu^- and can give S_N' product in acidic polar medium.
- Secondary kinetic isotopic effect + strong R^N tendency ($C^{\oplus}$)
- Generally dehydration
- 

⇒ **E_{1cB}** βH is sufficiently acidic but LG poor.

Step 1 

Step 2 

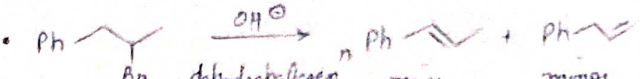
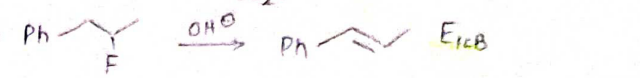
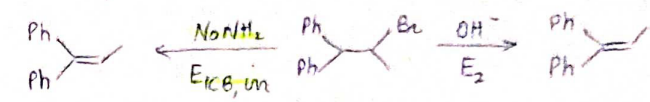
Case 1 When $C^{\oplus}$ stab by EWG at β C, K_1 high, $K_{-1} \to 0$, K_2 low → Step 2 rds → $\left(\frac{K_H}{K_D} = 1\right)$ → X D exchange

Case 2 When $C^{\oplus}$ not stab by EWG much, Step 1 reversible, Step 2 rds → $\left(\frac{K_H}{K_D} = 1\right)$ → (✓ D exchange)

Case 3 = Case 2 but EG better, Step 2 fast, Step 1 rds and irreversible, $\left(\frac{K_H}{K_D}\right) \geq 7$, X D exchange b/c irrev.

Case 4 Ion pair forms in Step 1 (rds), fast decomp in step 2 $\left(\frac{K_H}{K_D} \geq 7\right)$.

	E_1	E_2	E_{1cB}	E_2'
Ist	LG	Same term	H	
Base	weak	moderate	strong	
Intermediate	$C^{\oplus}$ stab	X	$C^{\oplus}$ stab	

- 
- 
- 

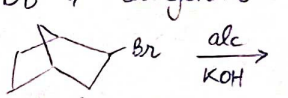
→ Orientation of DB

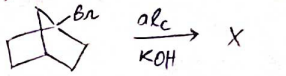
- More subs = major pdt

Major: SAYTZEFF Minor: HOFFMANN

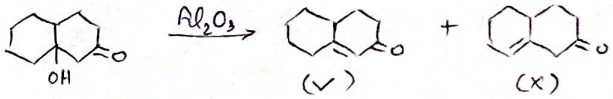
This is b/c TS has alkene like ch. & is more stable for Saytzeff.

- DB ≠ bridgehead

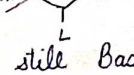


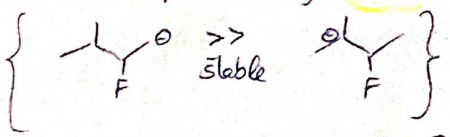


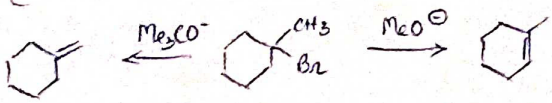
- Conjugation promotes elimination



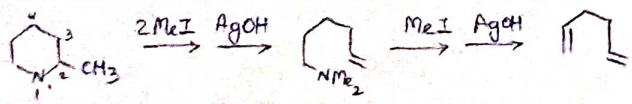
(Y) (X)

→ Although in  , $H_①$ is always more acidic than $H_②$, still Base attacks ② b/c $\Delta_{acidity}$ is v. less and base gives TCP. HOWEVER, when L = +ve charged ($^{\oplus}NR_3$, $^{\oplus}SR_2$), $\Delta_{acidity}$ ↑ and ∴ Hoffmann pdt ↑. Hoffmann pdt is also favoured by a v. bulky base (SH) and in case L = F (explained using E_{1cB}).



- 

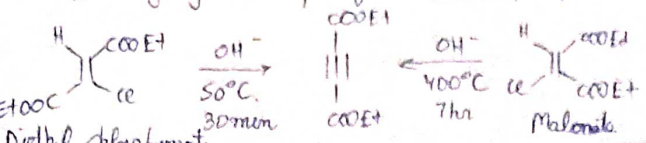
- Hoffmann exhaustive methylation followed by eliminat^n



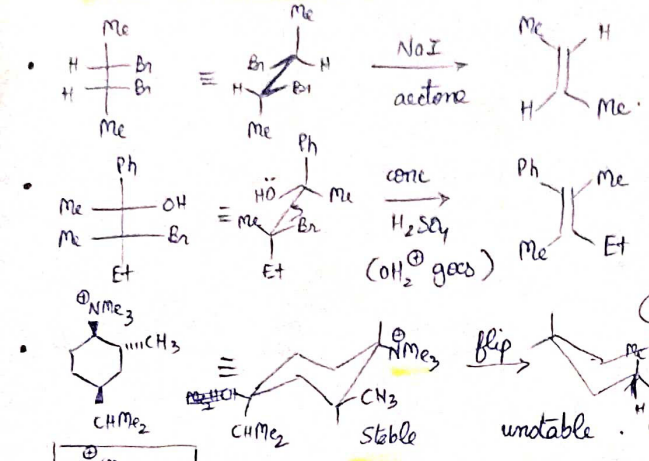
its isomers ῶ CH_3 at 1,3 and 4 give different products & can thus be differentiated.

→ **STEREOCHEMISTRY**

* E_2 – highly stereospecific – anti-periplanar

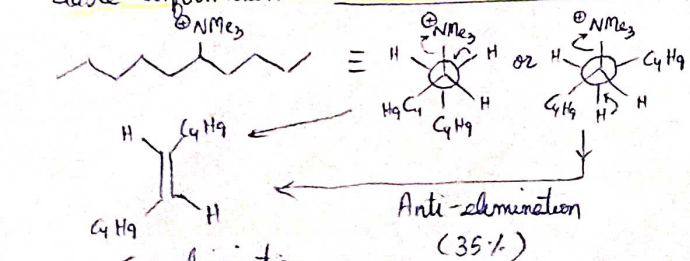


$E_{am} = E_{aF} + E_{rotation}$ → $E_{am} > E_{aF}$ → $k_m < k_F$



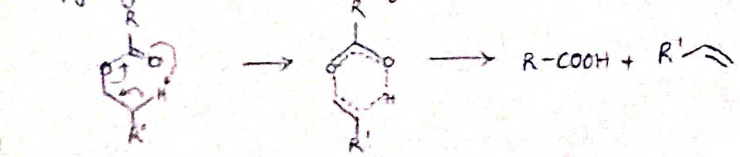
* E_1 – non stereospecific (After C⊕ form^n, free bond rotation).

• Acyclic case → If anti-periplanar not possible in stable conformation → SYN ELIMINATION @ slow pace



→ **E_i** (internal)

Ester having atleast 1 βH on alcoholic side undergoes pyrolysis at 400°C to give alkene via 6m TS.

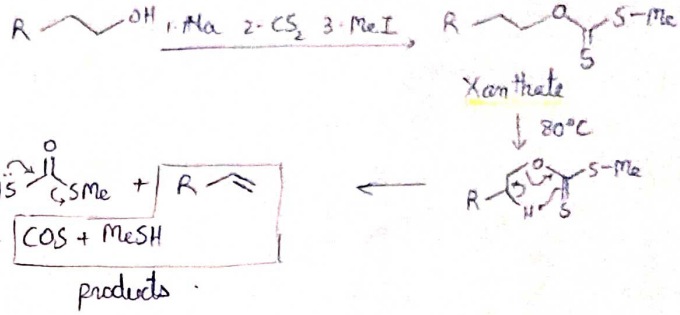


→ **COPE ELIMINATION** – Saytzeff major

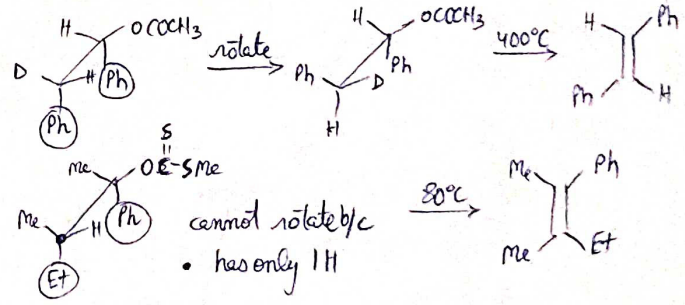
Amine oxide w atleast 1 βH reacts at 125°C giving alkene by E_i mechanism via 5m TS

(prepared by $R-NMe_2 + HNO_3 \rightarrow R-\overset{\oplus}{N}Me_2-O^{\ominus}$)

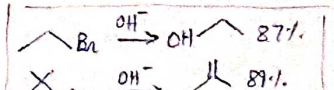
→ **CHUGAEV REACTION**



* SYN elimination meaning differs in cyclic & acyclic systems. For cyclic, it means 60° dihedral angle i.e. axial-eq. interaction. BUT. for acylic it means ~~0° dihedral when groups not v. bulky & 60° dihedral when groups v. bulky~~ ensuring minimum dihedral angle (either 0° or 60°) while ensuring minimum repulsion b/w bulky groups.



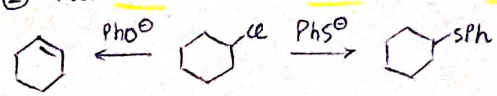
→ **WHICH MECHANISM ?**



① 1° → 2° → 3°

S_N2 — E_2 (↑SH ∴ ✗ S_N2, ↑ # αH ∴ E_2 ✓)

② More Nu⁻ base → S_N2, More Basic → E_2



③ E_2 @ higher T comp. to S_N2 (C-H bond strong)

④ 1° → 2° → 3°

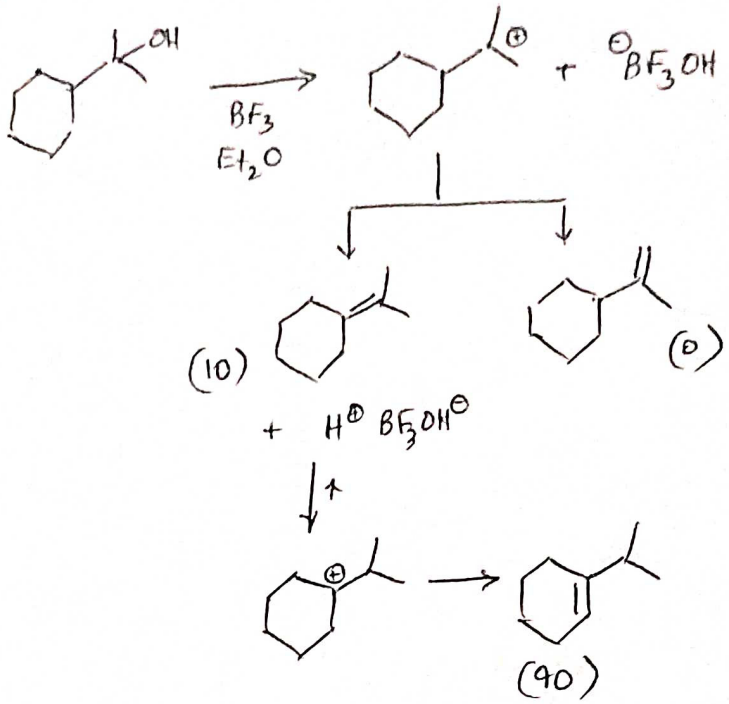
S_N1 — E_1

(HCl) S_N1 — E_1 (H_2SO_4 / H_3PO_4)

Nu⁻ / Base

⑤ E_1 @ higher T comp to S_N1

⇒ Re-protonation leads to isomerism of obtained products

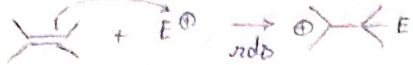


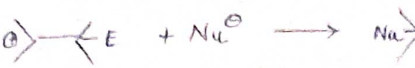
ADDITION RXNS

- Removal of unsaturation by add^n of complete molecule (both Nu^- & E^+ parts)

ELECTROPHILIC ADDITION

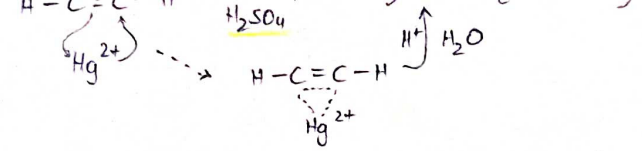
- Add^n to C=C (non polar)

Step-1 

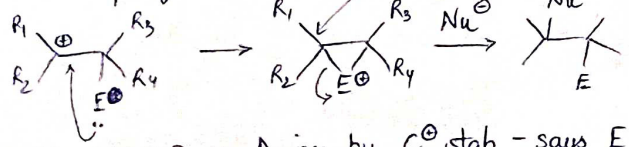
Step-2 

Rate = K_2 [Substrate][$E^\oplus$] Bimolecular

- Only aliphatic DB b/c aromatic DB will loose Arom completely. Since vinyl $C^\oplus$ unstab, alkyne gives no addition product under normal conditions. HOWEVER, initial polarisation by Hg^{2+} helps in $C^\oplus$ formation

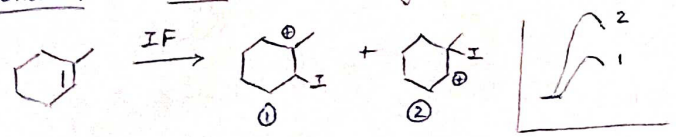


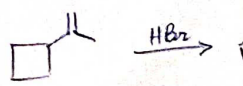
- Addition is not stereospecific ($CC^\oplus$) but can be regioselective / regiospecific if >1 reactive centres present for $E^\oplus$ attack. HOWEVER if $E^\oplus$ has lone pair, cyclic $C^\oplus$ forms (10 Kcal more stable). Now $Nu^\ominus$ attacks only from opp side (Stereospecific)

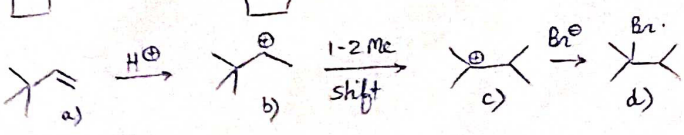


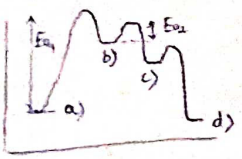
- MARKONIKOFF → Driven by $C^\oplus$ stab - says E^+ attacks at less substituted centre of an alkene.

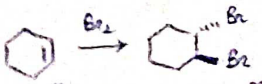
Condition → Both alkene & reagent must be asym.

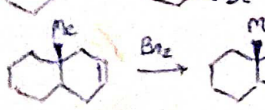


- 

- 

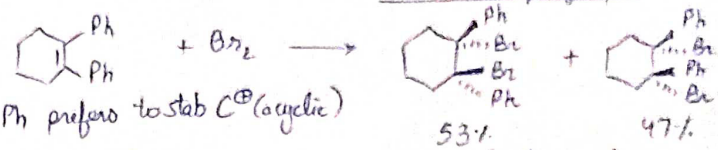


- 



more stable

- If some factor extra stab acyclic $C^\oplus$, cyclic $C^\oplus$ may not form sufficiently. Thus ↓ stereospecificity



Ph prefers to stab $C^\oplus$ (acyclic)

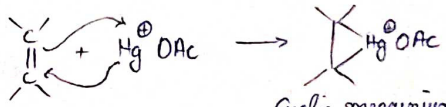
53% (↓ stereosp.) 47%

- ↑ Solvent polarity also stab acyclic $C^\oplus$ more & ↓ stereosp.
- Stability order of cyclic halonium ions $I^\oplus > Br^\oplus > Cl^\oplus$

Q. HOW TO GET 100% STEREOSPECIFICITY ?

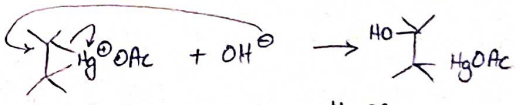
(I) OMDM (100% anti product) - HYDRATION

Step-1 $(CH_3COO)_2Hg \longrightarrow Hg^\oplus OAc + AcO^\ominus$

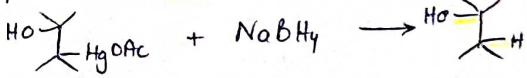
Step-2 

Cyclic mercurinium ion

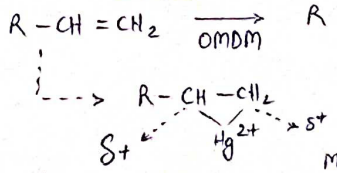
Step-3 Add NaOH

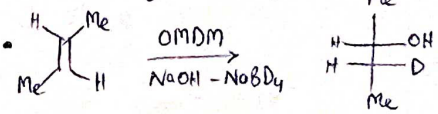


Step-4 Add $NaBH_4$ to remove $HgOAc$

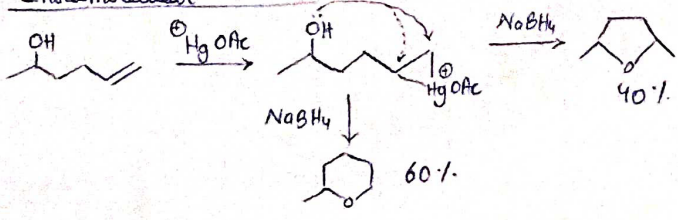


* OMDM always gives more subs alkene.



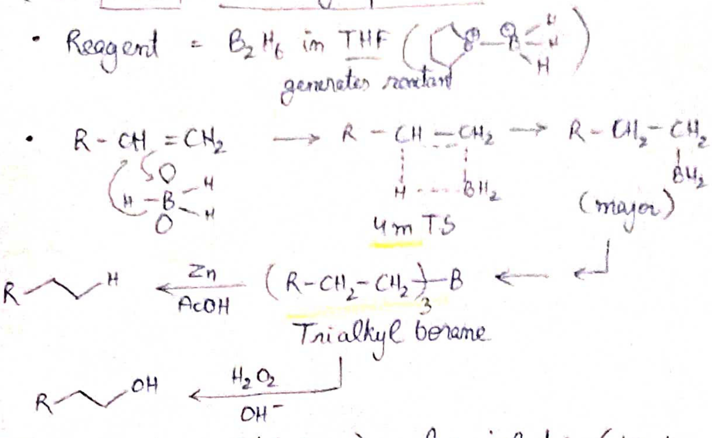
- 

- No R^N in OMDM
- Intramolecular OMDM

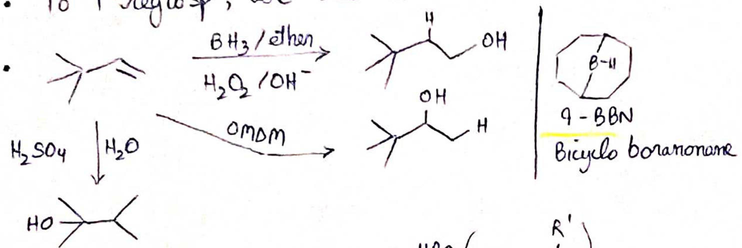


(II) HBO — 100% syn product

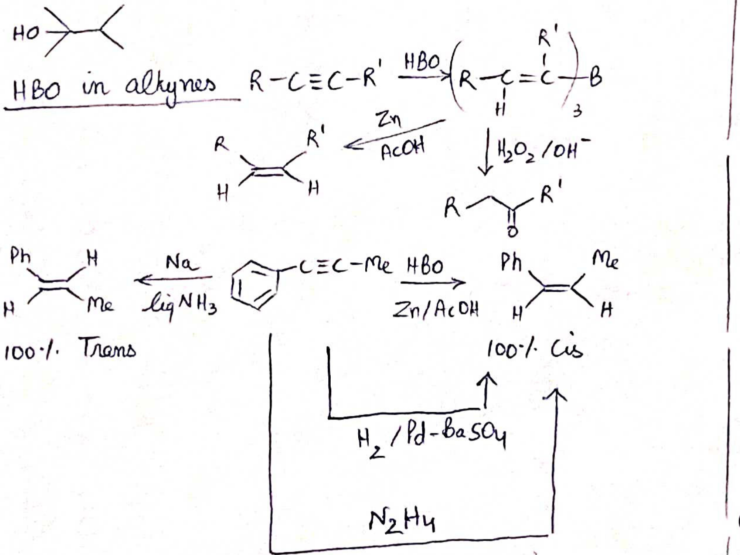
- Reagent = B_2H_6 in THF (complex shown) generates reactant



- Highly stereospecific (syn) + Regioselective (b/c 4m TS already unstab ∴ boration from less subs)
- To ↑ regiosp, use bulkier borane or bulkier substrate.

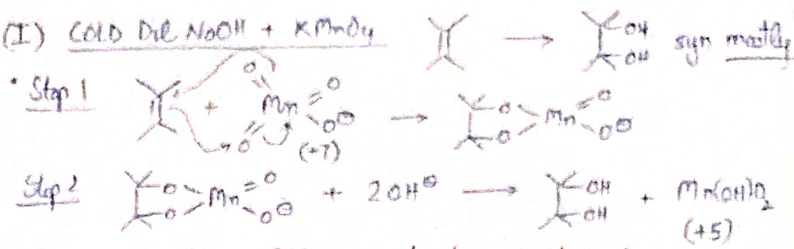


- HBO in alkynes



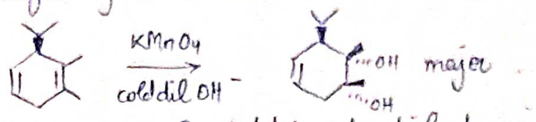
⇒ OXIDATIVE ADDITION

(I) COLD Dil NaOH + $KMnO_4$

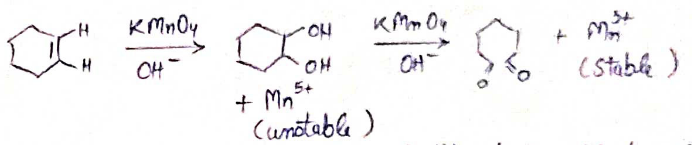


- Process is stereoselective, not stereospecific b/c Step 2 ring opening may not always be simultaneous

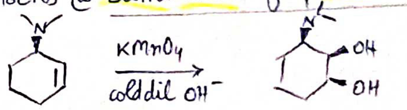
⊙ Preferably @ e⁻ rich site and @ opp side of bulky subs



- PROBLEM – Reoxidation of diol to give ring cleavage pdt

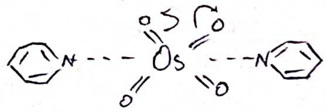


⊙ Attacks @ same side of polar substituent (coordinates w Mn)



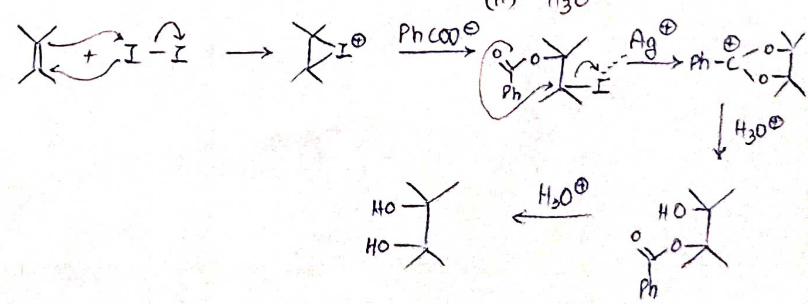
(II) OsO_4 ⊙ same as above, mech same

- Major advantage = No RE-OXIDATION
- OsO_4 bonds are strong → use Py to ↑ e⁻ density around it & make Os=O mobile. Since OsO_4 expensive, add OA like HIO_4 to recover reduced catalyst ($OsO_3 \rightarrow OsO_4$)

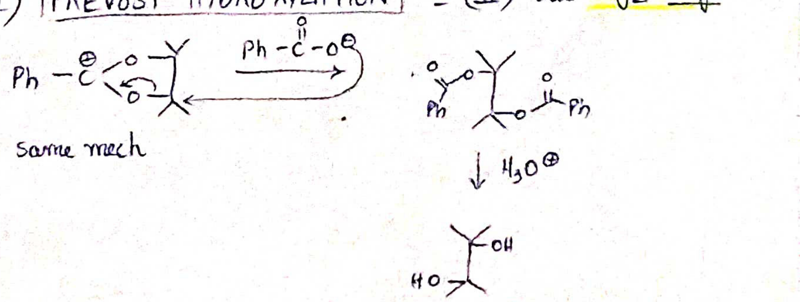


(III) WOODWARD HYDROXYLATION

(i) I_2 / Ag_2O (moist) / $PhCOO^-Na^+$
(ii) $H_3O^{\oplus}$



(IV) PREVOST HYDROXYLATION ≡ (III) but Ag_2O dry

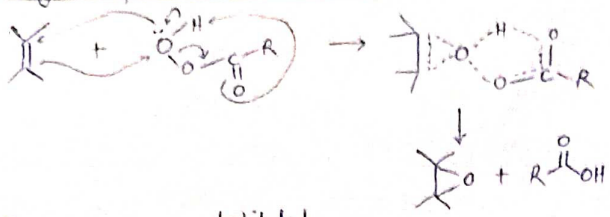


* Both III & IV → attack @ high e⁻ density + NO GUIDANCE of polar substituent.

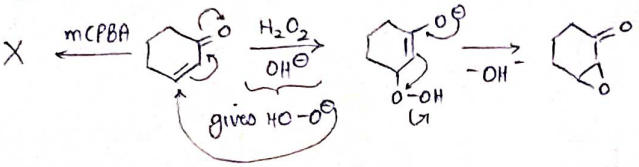
(V) EPOXIDATION

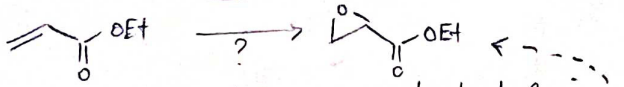
* Peracetic acid (PAA), Trifluoro (TFPAA), H_2O_2, Perbenzoic acid (PBA), mCPBA, H_2SO_5 (Caro acid)

- Single step concerted meth



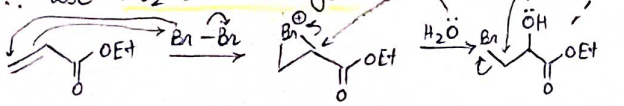
- Rxn @ more substituted
- Peracids do not react when EWG attached to alkene, so we use H_2O_2/OH^- - but it gives MICHAEL ADDITION PRODUCT



- 

H_2O_2/OH^- X b/c base causes ester hydrolysis

∴ use Br_2 in moist Ag_2O

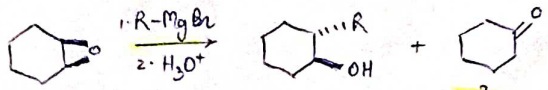


- Epoxide ring opening :

① ῶ Base → S_N2 → stereospecific (gives trans diol)

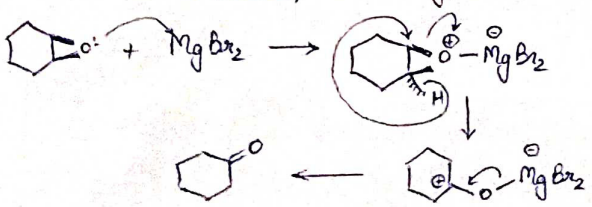
② ῶ acid → S_N1 → Cis Trans diol mix

③ ῶ Lewis Acid → epoxide undergoes Rearrangement.

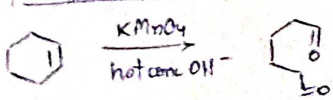


R-Br $\xrightarrow[\text{ether}]{Mg}$ R-MgBr

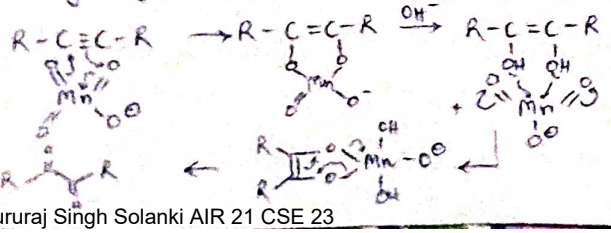
R-MgBr | RBr → R-R + $MgBr_2$ (acts as LA)



(VI) OXIDATIVE CLEAVAGE

- 

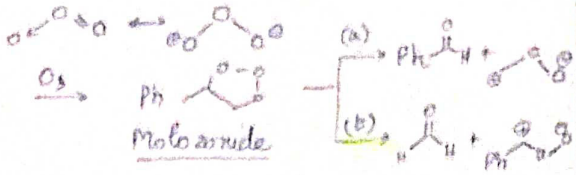
- Alkynes give vicinal carbonyl (not cleavage)



* Ozonolysis

- Reductive ozonolysis - gives A/K - use Zn/Me_2S (RA)
- Oxidative ozonolysis - gives K/Carboxylic acid - use H_2O or H_2O_2

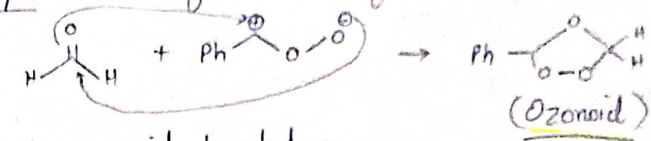
→ Mechanism



(b) occurs, not (a) b/c C$^\oplus$ stable only in (b)

Step-2 Breaking of molozonide (done)

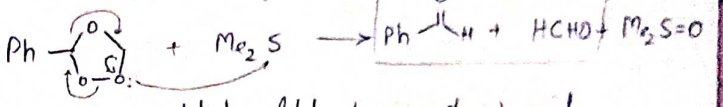
Step-3 Formⁿ of Ozonide (from (b) in this case)



(Ozonoid)

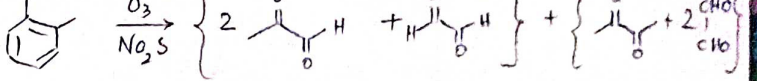
Step-II Ozonoid breakdown

① When RA present eg. Me_2S



② When H_2O_2 added, aldehyde converts to acid

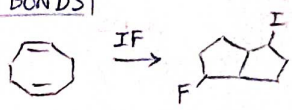
so products = Ph-COOH + HCOOH

- Helps to identify nature & position of alkenes.
- 

DO NOT FORGET RESONANCE.

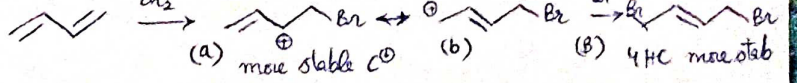
- $R'-C\equiv C-R \xrightarrow[Zn]{O_3} R'-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-R + ZnO$.

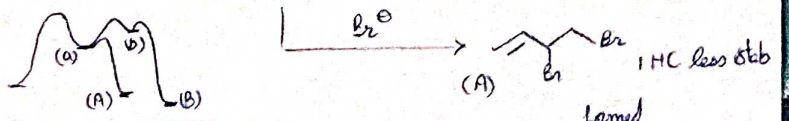
(VII) >1 DOUBLE BONDS

① Isolated DB 

② Conjugated DB (Allylic system)

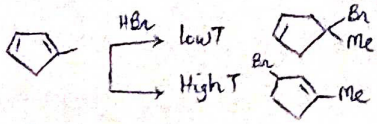
* Cyclic halonium ion NOT FORMED b/c acyclic C$^\oplus$ stable.

- 



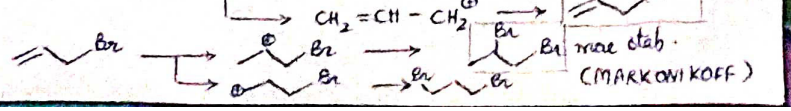
(a) → (b) requires higher T ∴ (B) = TCP formed @ high T

(A) = KCP from more stab I^e

- 

③ Cumulative DB ⇒ 2 additions

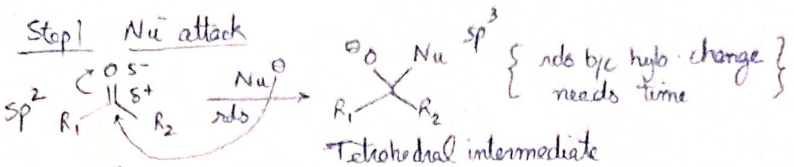
(i) $CH_2=C=CH_2$ → $CH_2=\overset{\oplus}{C}-CH_3$ / $CH_2=CH-CH_2^\oplus$ → (ANTI-MARKONIKOFF) Br

(ii) 

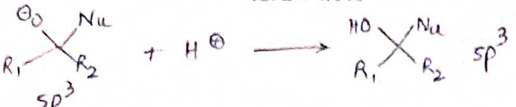
NUCLEOPHILIC ADDITION RXNS
(polar multiple bonds)

→ Mechanism

Step 1 Nu⁻ attack



Step 2

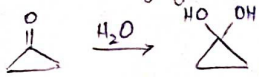


Rate = K_2 [substrate] [Nu^-] Bimolecular (Ad^2_{Nu})

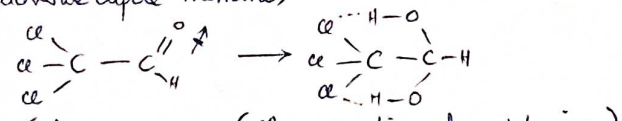
→ Aldehydes > Ketones > Aromatic (lowest δ⁺)
(sp^3 has more SH + K already has less δ⁺)

→ Cyclic Ketones ~ aldehydes b/c rigid ring → less repulsion

→ Strain relief gives exceptionally high rates.



- Chloral exists as chloral hydrate b/c it is unstab. (advance dipole moment)



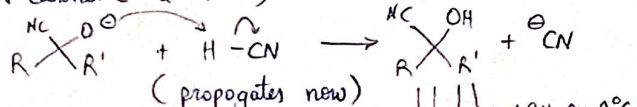
(Cl → H-Bonding when >1 rings)

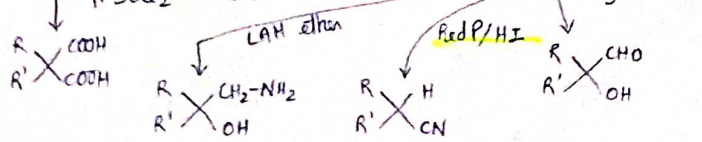
→ ERG ↓ & EWG ↑ reactivity.

→ **REACTIONS**

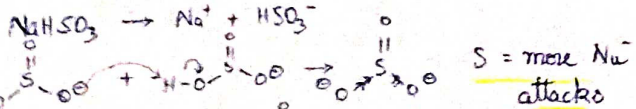
(I) **CYANOHYDRIN** {general mech}

- CN^- v. good Nu^- ∴ C electrophilicity or SH unimp.
- NaCN (small amt) + HCN can be used. But pure HCN cannot ($K_a = 10^{-9}$)

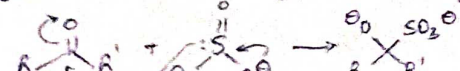




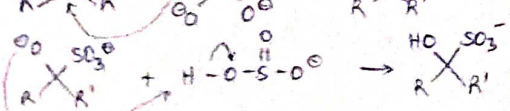
(II) **BISULPHITE FORMATION**



Step 1



Step 2

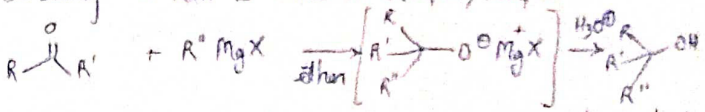


- All aliphatic aldehydes
- Only Methyl Ketones in Ketones (separation of Ketones → $SO_3^-Na^+$ type salt in aq, rest Ketones in organic phase)

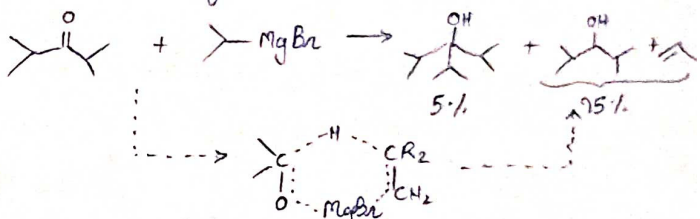
(III) **GRIGNARD ADDITION**

∴ $R^⊖$ is enough Nu^- but not base for Normal A/K

- When a 3° alcohol is produced it has strong dehydration tendency ∴ Rxn is done in NH_4Cl/NH_4OH

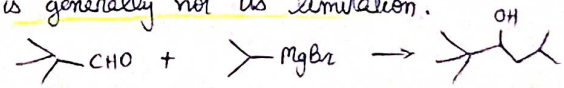


- Bulky alkyl is introduced by GR in event of choice
- If either of Carbonyl or GR are v. bulky, GAR does not give addition product. Carbonyl is reduced to its alcohol form and GR is wasted (6m TS)

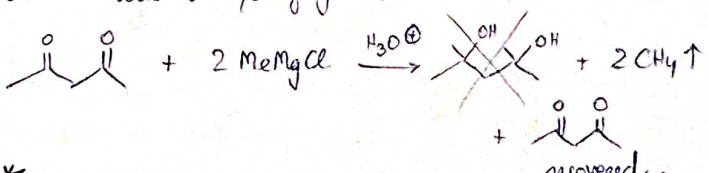


Grignard add" is competition b/w hydride & alkyl transfer. Alkyl transfer favoured by high 'C' electrophilicity but discouraged by SH. HOWEVER hydride transfer can occur when GR has β-H.

- Since aldehyde has H (small, ↓SH), hydride transfer is generally not its limitation.



- Carbonyl having significantly acidic α-H (case of β-diketone) creates problem b/c GR acts like base and is wasted w/o grignard addition.



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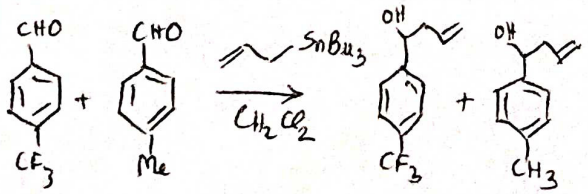


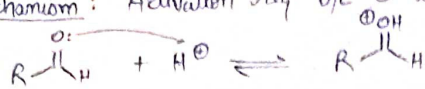
→	120°C	64%	Trace
→	with BF_3, Et_2O	21%	63%

Lewis acid forms complex with Carbonyl O and activates Carbonyl giving high reactivity. This complex is more stable when ERGs present.

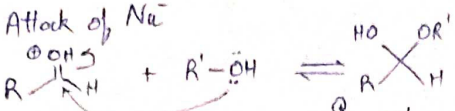
(IV) ACETAL

→ Mechanism: Activation req b/c 'O' weak Nu^-

Step 1

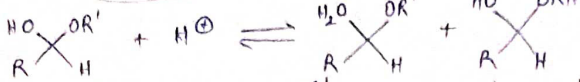


Step 2 Attack of Nu^-

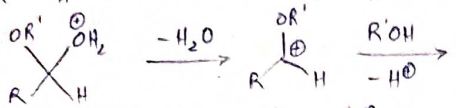


Hemiacetal

Step 3

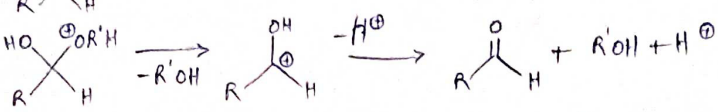


Step 4a



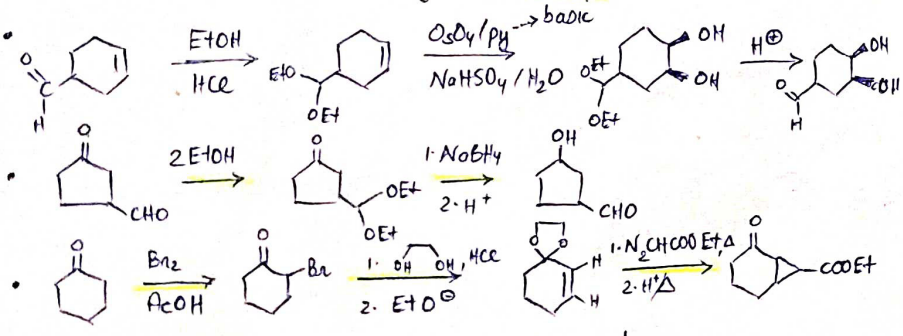
Acetal

Step 4b

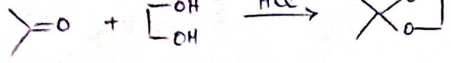


Since protonation tendency of OR' > OH, decomposition tendency of hemiacetal is higher than its conversion to acetal ∴ Acetal continuously distilled out & ph kept above 5·8.

* Acetal unstab. in acidic medium but quite stable in basic medium ∴ used as **Carbonyl Protection**.



* Cyclic acetal formation is highly favoured.



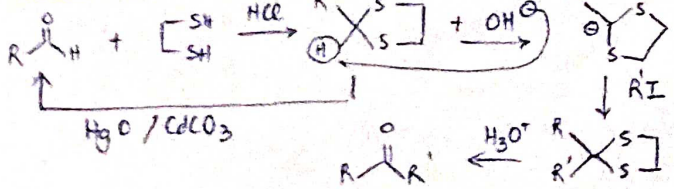
if 6m can form, it is favoured over 5m ring.

* Ketones, being less reactive do not give this rxn unless cyclic acetal is formed.

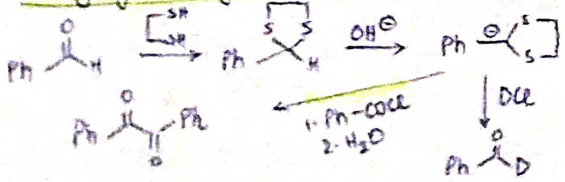
→ THIOACETAL (S = good Nu^-)

* Stable in acidic medium (S = less protonation tendency)
* Used for :-

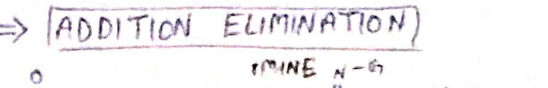
① Aldehyde to Ketone



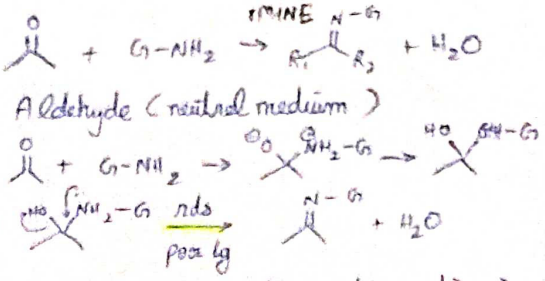
② Changing Carbonyl substituent



(V) ⇒ ADDITION ELIMINATION



① Aldehyde (neutral medium)

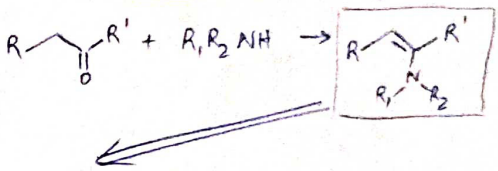


When Ketone (always in acidic medium) step 1 becomes rds b/c 2 fast

② If pH v. low, $G-NH_2$ → $G-\overset{\oplus}{N}H_3$ deactivated

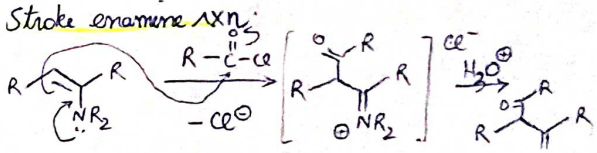
③ G = H / Ph / -OH / 

④ When amine = 2° rxn gives enamine

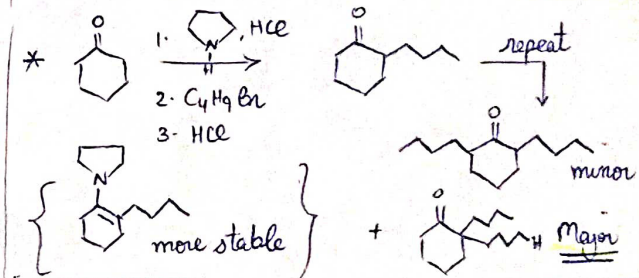


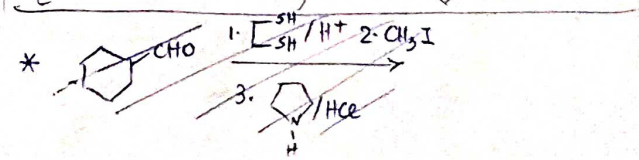
α-ALKYLATION

Stroke enamine rxn:



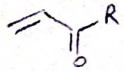
β-diketone

* 



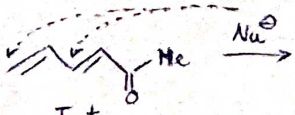
*

* If EWG is attached, MICHAEL ADDITION can occur when : R bulky / v. less Nu^- which needs high E^+ centre

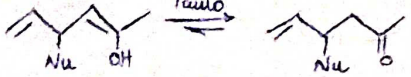


- R_2CuLi – only michael (Gilman)
- RLi – only normal addition
- Grignard – both based on SH

* VINYLOGY



a)



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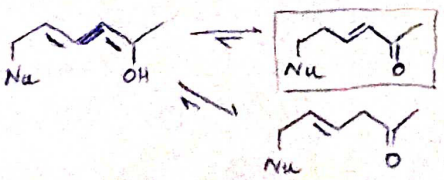
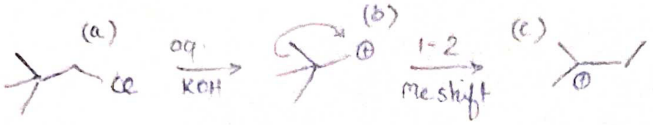
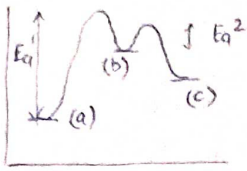


Most stable others not formed

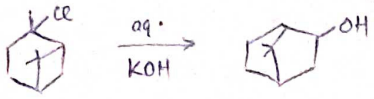
REARRANGEMENTS

WAGNER MEERWEIN

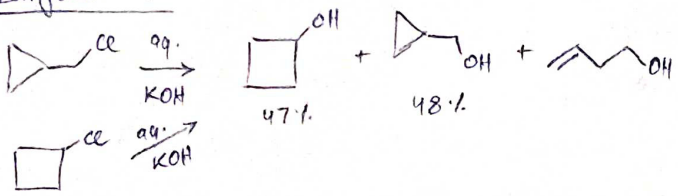
- 



$K_2 > K_1$ R^N due to Kinetic factor ∴ WMR only concerned w intermediate stability.

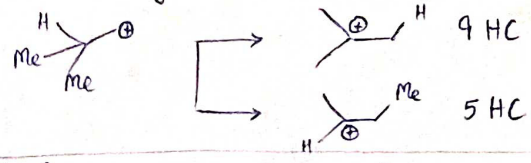
- 

- Demjanov R^N



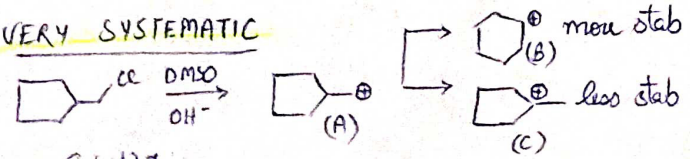
→ MIGRATION TENDENCY = f (stab of TS of intermediate, stab. of final rearranged pdt)

- Aryl TS stab by (+M) highly stab.
- 3° stab by HC > 2° > 1°
- H has more tendency than Me b/c final R^N pdt is better stab by HC when H migrates.



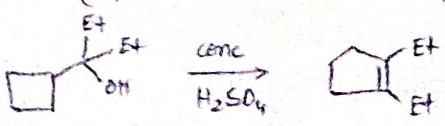
Aryl > Ph > 3° > 2° > 1° > H > Me
EAG

* When asked about most stable pdt formed, BE VERY SYSTEMATIC

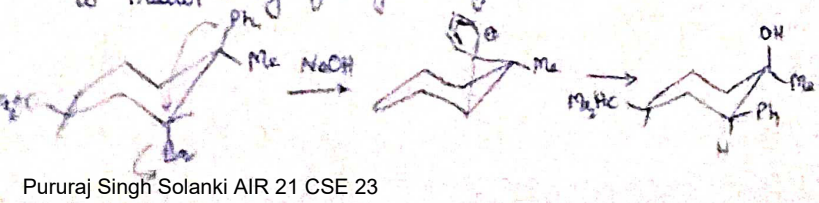


Substitution (A) (B) (C) Elimination (A) (B) (C)

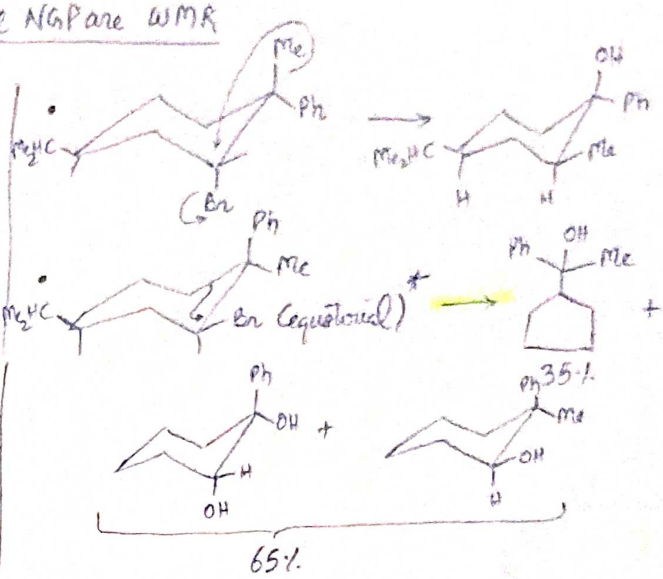
- Since OH⁻ = weak base but strong Nu → Subs major From (B) → most stable subs pdt.

- 

* Only Trans migration occurs in WMR. This seems to matter only for cyclic systems.

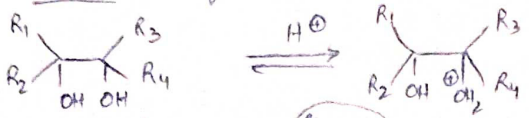


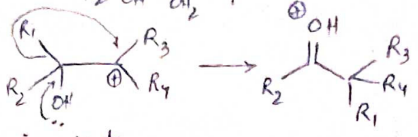
* All NGPare WMR



PINACOLE PINACOLONE R^N

- Substituted vicinal diol placed in acidic medium gives a mixture of 3° substituted ketones called Pinacolone
- Vicinal diol is not v. stable (push factor of OH⊕) As soon as C⊕ forms, pull factor ✓ and Ketone can form (more stable than vicinal diol)

(i) 

(ii) C⊕ formation (iii) 

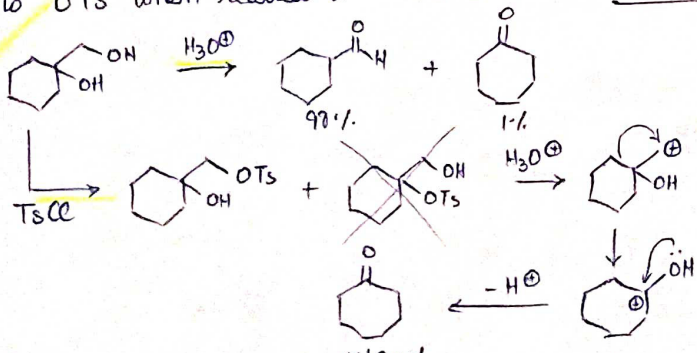
(iv) deprotonation to give Ketone.

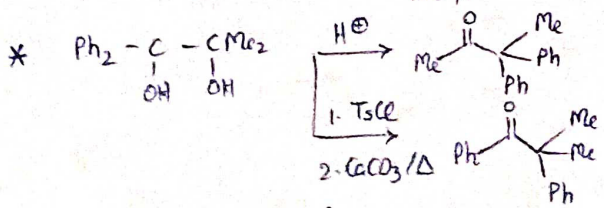
- PPR = Thermodynamic R^N based on pdt stability. The dominant pdt is formed always from most stable C⊕.
- Since Ketones are more stable than aldehydes, H migrates if present ∴ H >> Aryl > aryl > Alkyl > 3° > 2° > 1° > Me (ERG: Aryl, aryl; EWG: Alkyl)

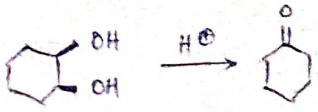
- HOW TO FORM product from less stable C⊕ as Major?

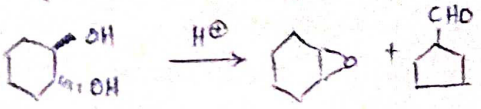
PPR is general R^N. We only need good lg.

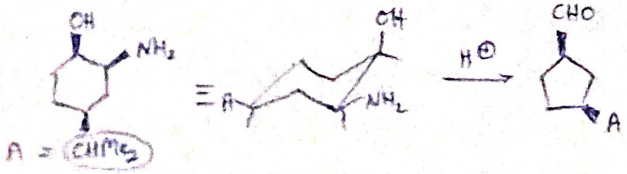
∴ We employ OTs (bulky ∴ only that OH converts to OTs when reacted w TsCl which is less subs)

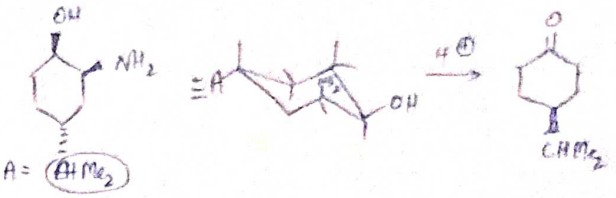
* 

* 

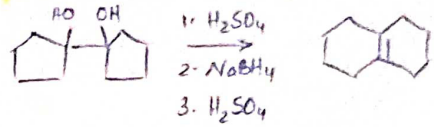
- 

- 

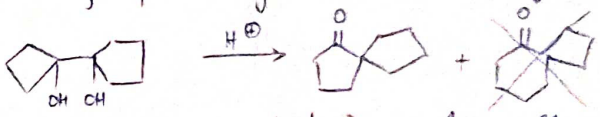
- 

- 

NOTICE ORIENTATION OF RING BASED ON POSITION OF $CHMe_2$

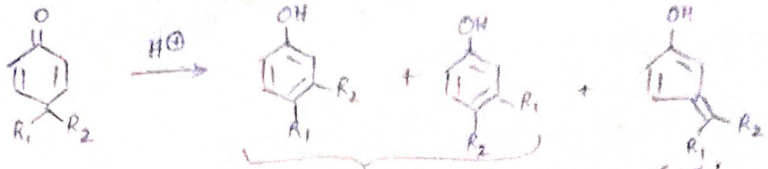
- 

One ring expanded by PPR and other by WMR

- 

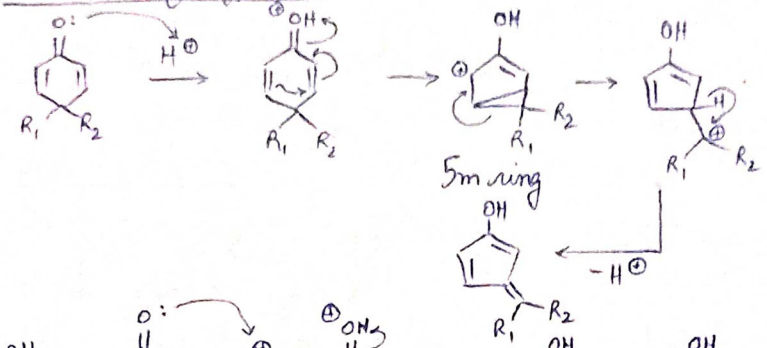
In event of choice, only smaller ~~bigger~~ ring migrates.

DIENONE - PHENOL RN

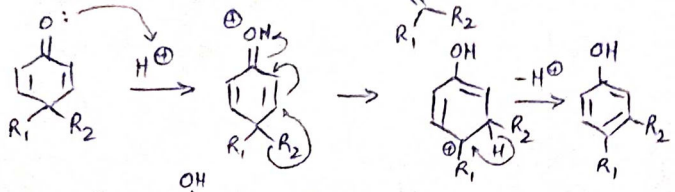


Major & minor depending upon relative migration tendency.

① Formation of Byproduct



② Other



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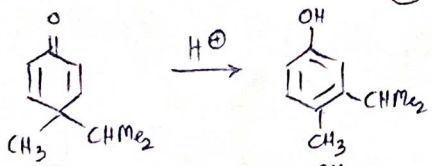

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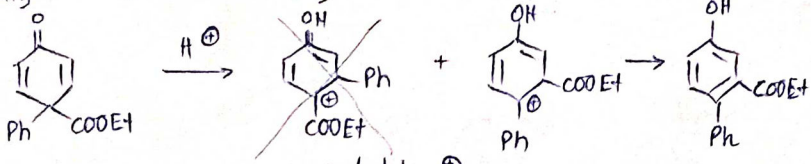
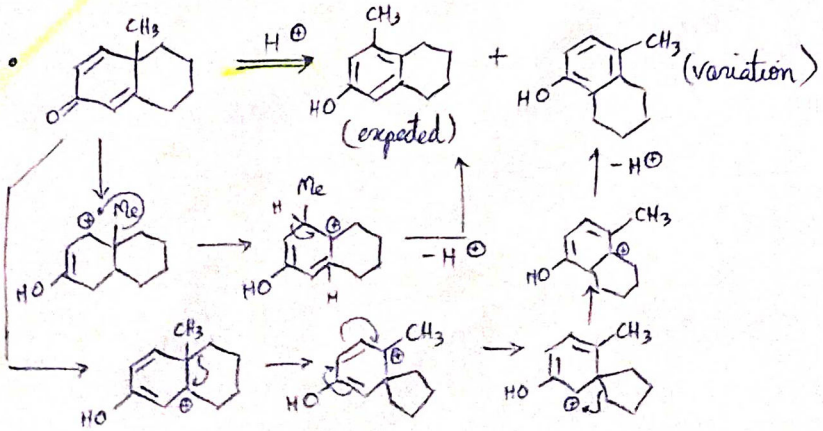


In the case of EWG, only EWG migrates always to avoid unstable C⊕.

•



BAEYER VILLIGER OX^N

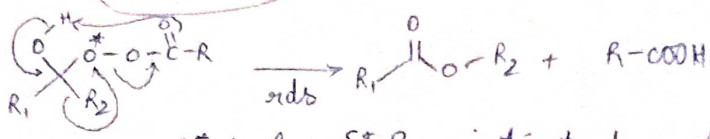
Ketone + per acid → mix of esters (ox^n ω R^N)
one major

- **Mechanism:**

Step 1

Step 2

Step 3



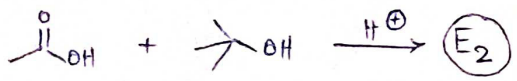
rds

O^+ develops δ^+ & migration tendency of R_2 depends upon its **Nucleophilicity** *

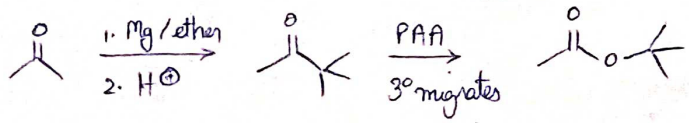
3° >	acyl	> 2° >	acyl	> 1° > Me
	ERGs		EWGs/ Benzene	

- R_2 migration = intramolecular → 100% retention of config^n
  → No cross products ω multiple reactants.

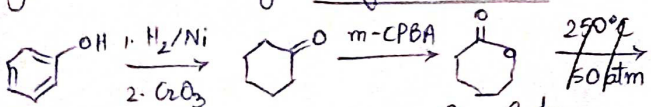
- Used to make 'DIFFICULT TO FORM' ESTERS



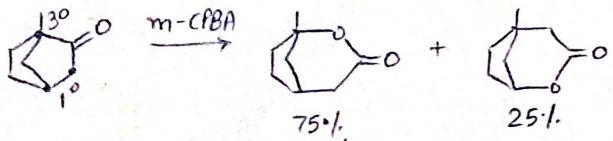
? How to get ester?

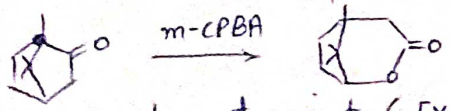
* 

- Cyclic esters undergo **Ring expansion**



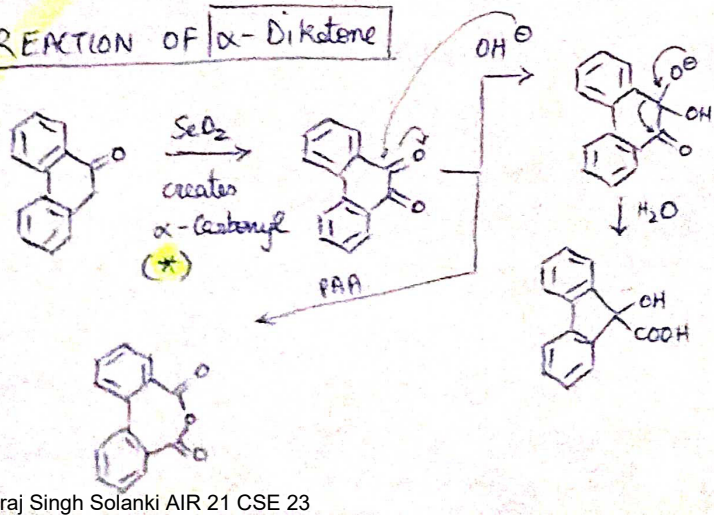
Caprolactone

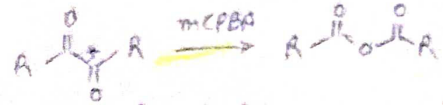
* 

* 

SH 30 • does not migrate (EXCEPTION) inspite of being 3°.

- **REACTION OF α-Diketone**



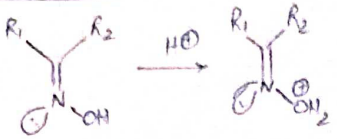
- 

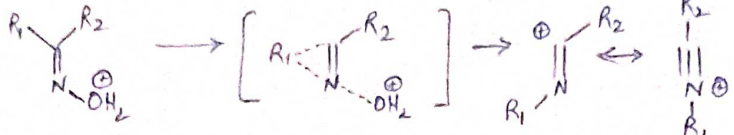
R does not migrate b/c LG during rds creates δ+ve on * Carbon which Carbonyl cannot stabilise but R can!

BECKMANN RN

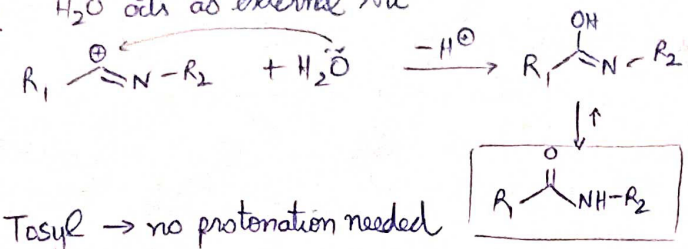
* Oxime of A/K reacts w protonic / Lewis Acid to give substituted amides depending on stereochem situat°

* Mechanism:

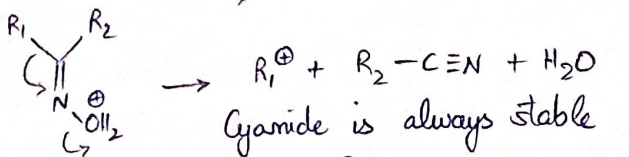
Step-1  Protonation

Step 2 Migration 

Step-3 H_2O acts as external Nu



- If Tosyl → no protonation needed
- TRANS MIGRATION (MOSTLY!) → used to distinguish oximes

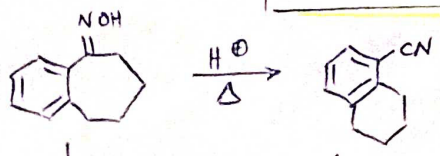
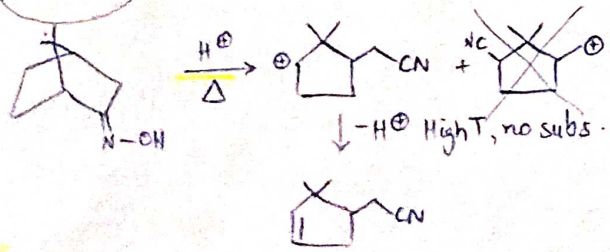
Step-2 

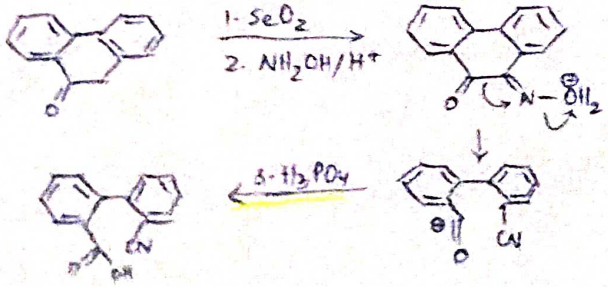
Cyanide is always stable

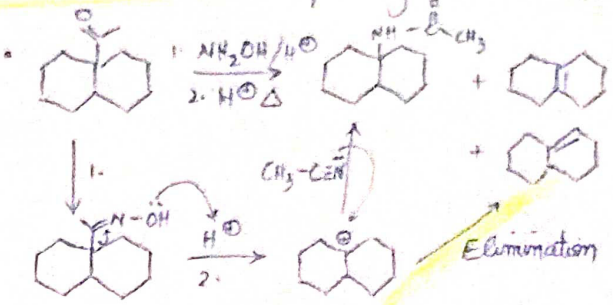
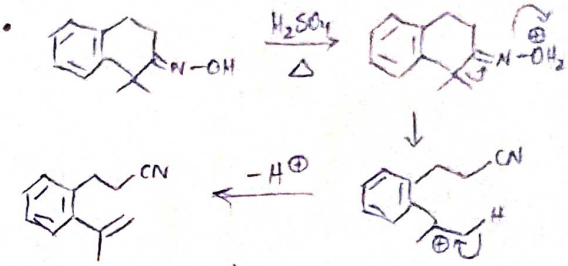
but its formation depends on $R^{\oplus}$ stability

3° $CHPh_2$ CPh_3

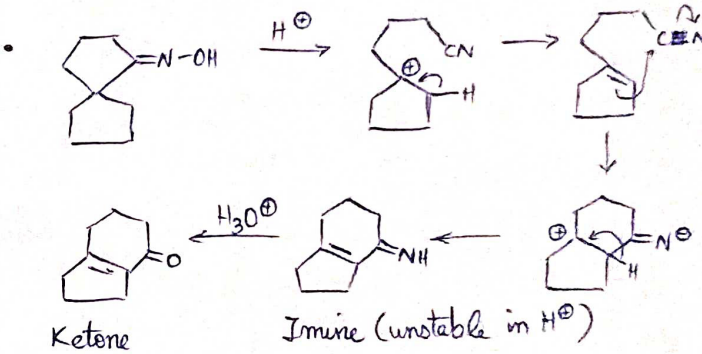
BECKMANN FRAGMENTATION

- 
- 
- Fragmentation occurs when ring cannot expand.



- 
- 

extended conjugation

- 

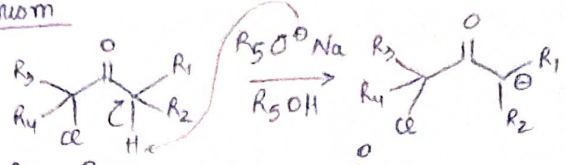
Ketone Imine (unstable in $H^{\oplus}$)

FAVORSKII RN

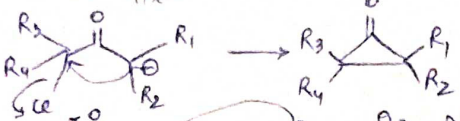
* α-halo ketone ⓦ atleast one α-H on alternate side undergoes A^N in presence of alkoxide base ~~in presence of~~ to give pair of ~~as~~ mixture of esters

* Mechanism

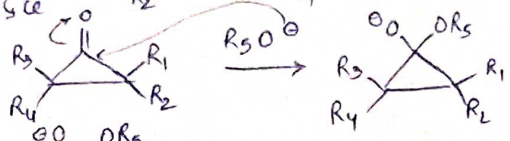
Step-1



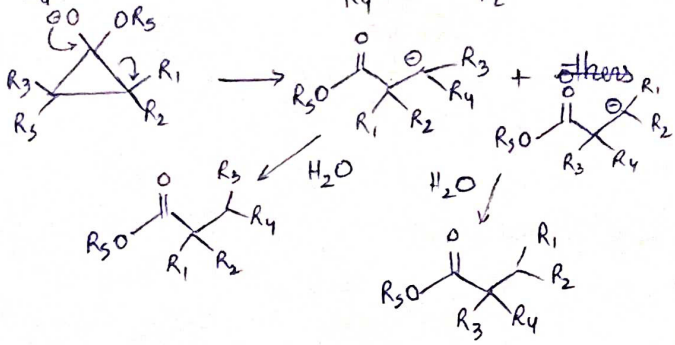
Step-2



Step-3

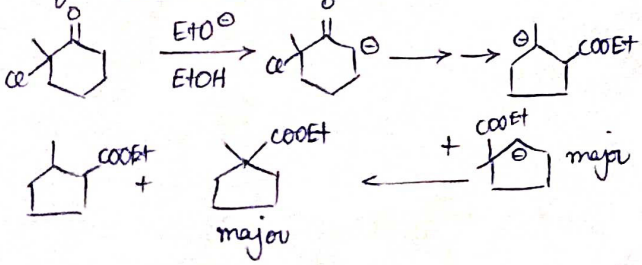


Step-4

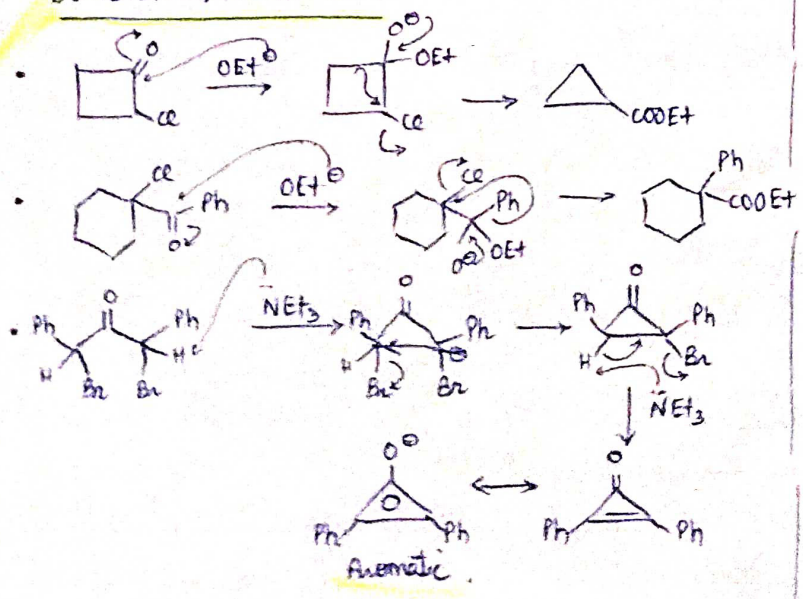


* $C^{\ominus}$ stability in Step 4 decides major pdt.

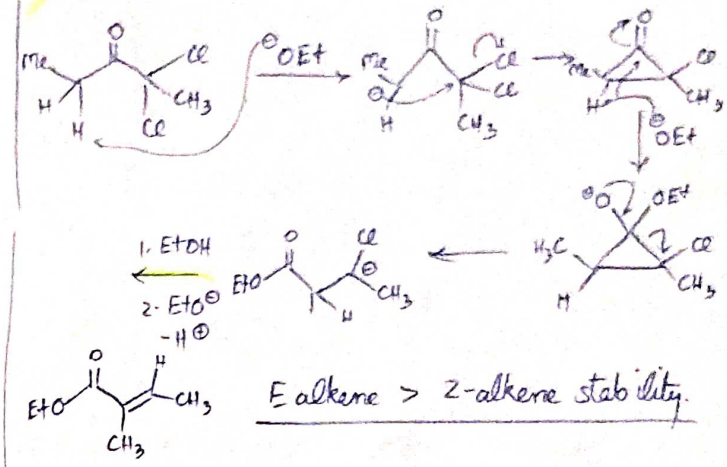
* Used for RING CONTRACTION



* In case of highly unstable intermediate (3 m rings are >1) or no α-H, do SEMI-BENZILIC MECHANISM

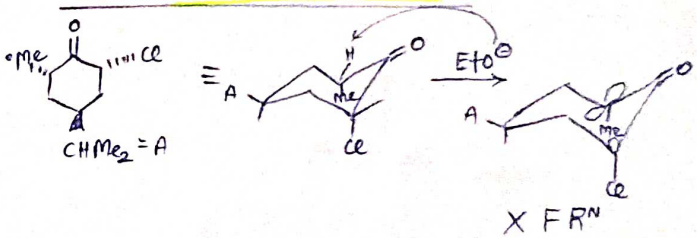


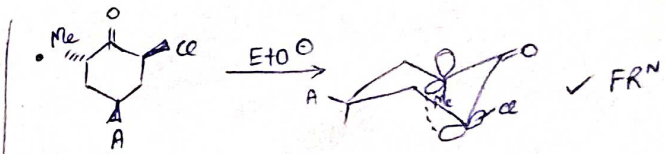
* >1 Halogen atoms case



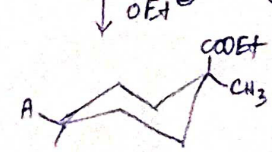
E alkene > Z-alkene stability

* MIND STEREOCHEMISTRY



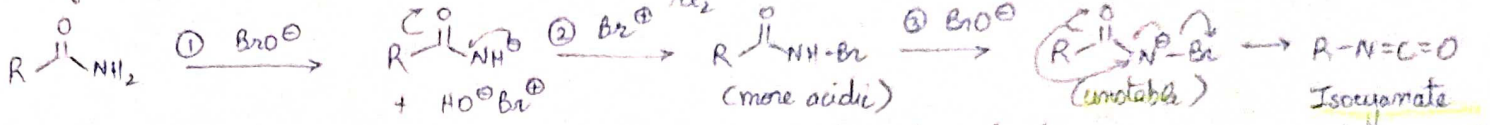


Retention of attack site (in this case at eq.)

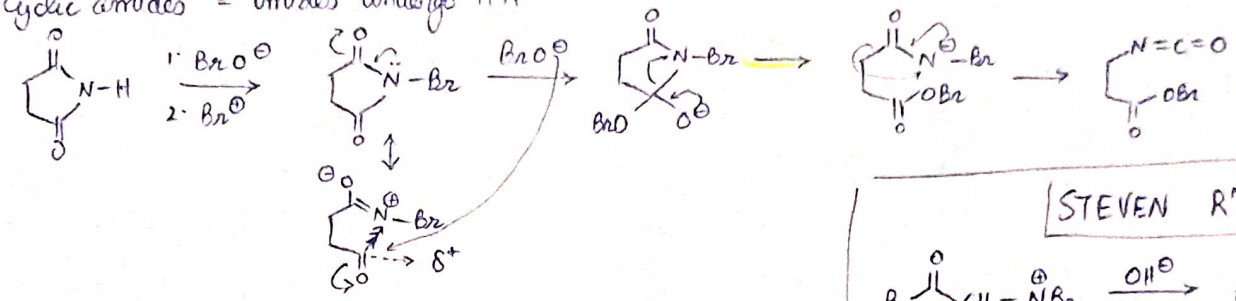


HOFFMANN R^N

* Primary amide heated w alkaline soln of Br_2/gives a primary amine with one 'C' lost as CO_2



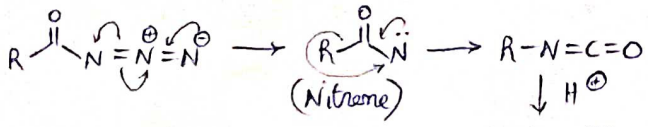
- Intramolecular migration (no cross products) + 100% Retention of configuration
- Cyclic amides ≡ imides undergo HR^N



- Not useful for base / Br sensitive functional groups.

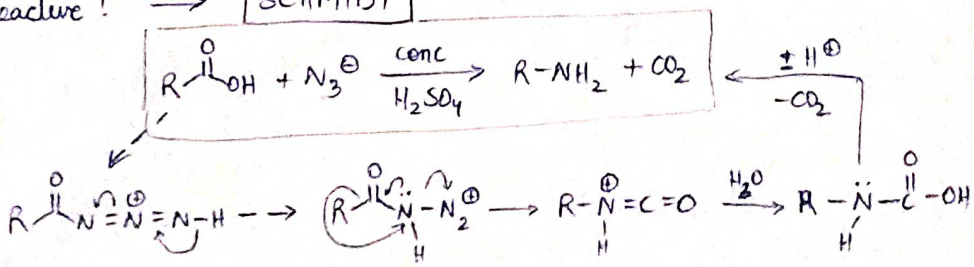
CURTIUS

Azide $\xrightarrow{\Delta}$ isocyanate $\xrightarrow{H^\oplus}$ amide



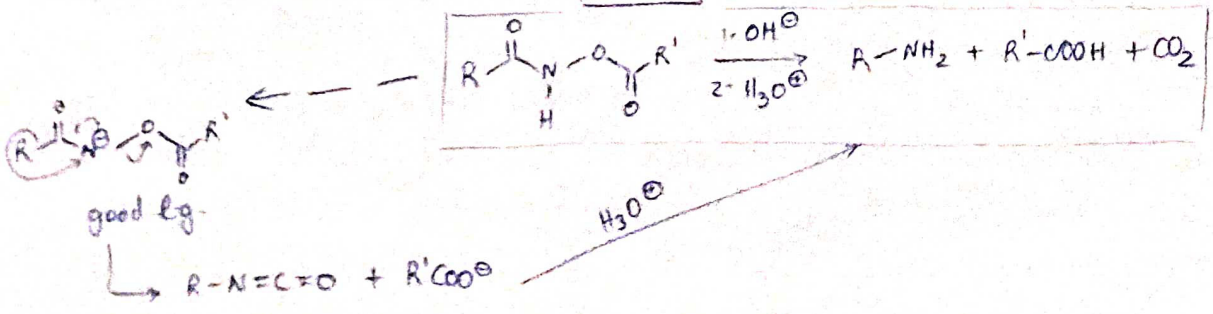
- But to prepare azide

use $R-CO-OH$ but less reactive! ⟹ **SCHMIDT**

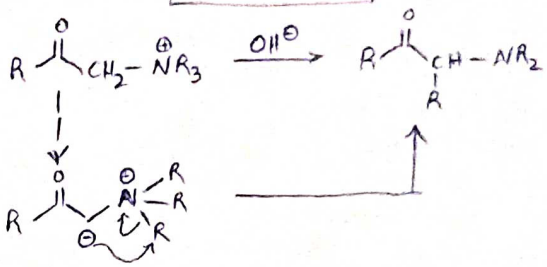


But conc. H_2SO_4 = strong OA.

LOSSEN

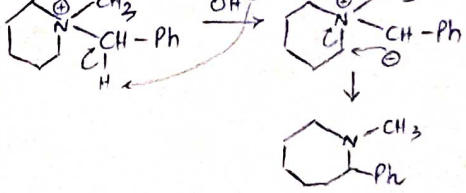


STEVEN R^N



Doubtful mechanism.

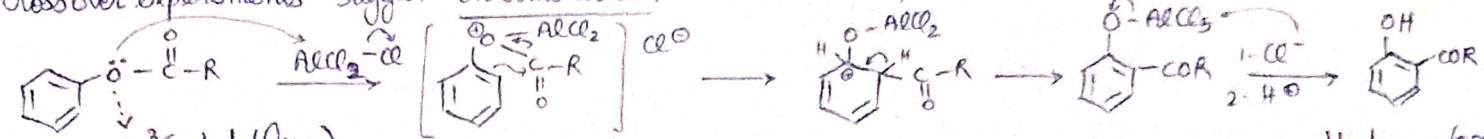
* RING EXPANSION = major usage (any size)

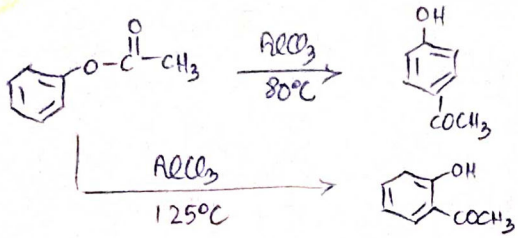


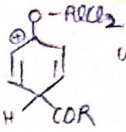
* Finally → Best = Hoffmann, just control rxn conditions

FRIES R^N

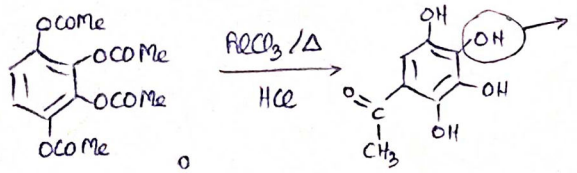
- When phenyl alkanoate + Lewis Acid $\xrightarrow{\Delta}$ followed by acidification $\rightarrow$ o & p hydroxy ketone. (Phenyl)
- Cross over experiments suggest intermolecular R^N (not intra)

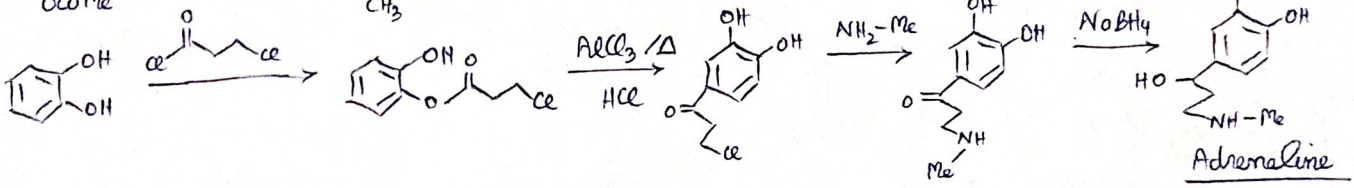


* 

Hydrogen bonding
(ortho = TCP)
BUT Para = KCP b/c

intermediate more stable.

But when any of the ortho are blocked, product = para irrespective of T.

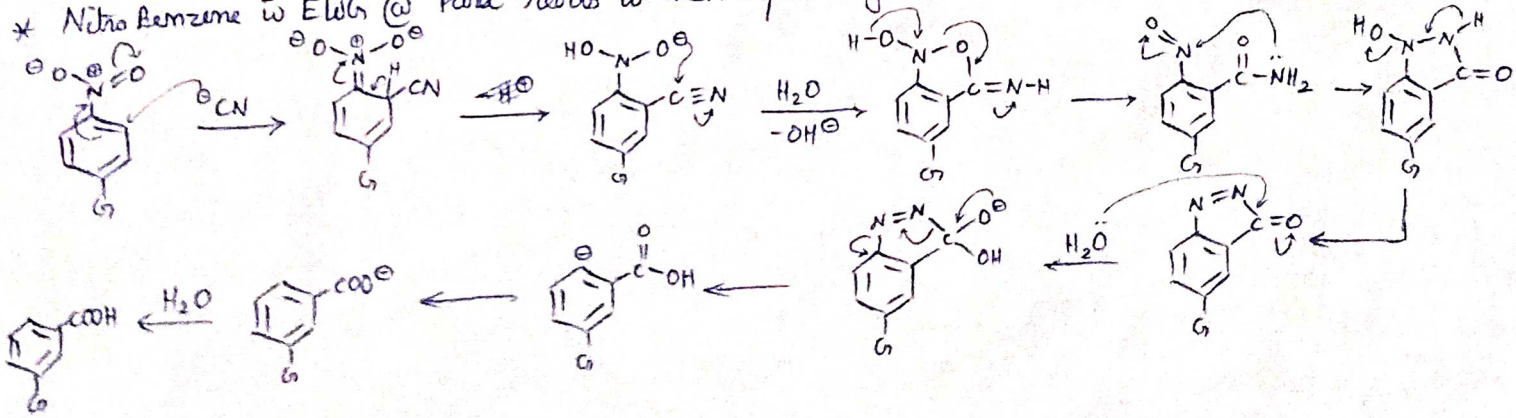
- 

- 

VON RITCHER R^N

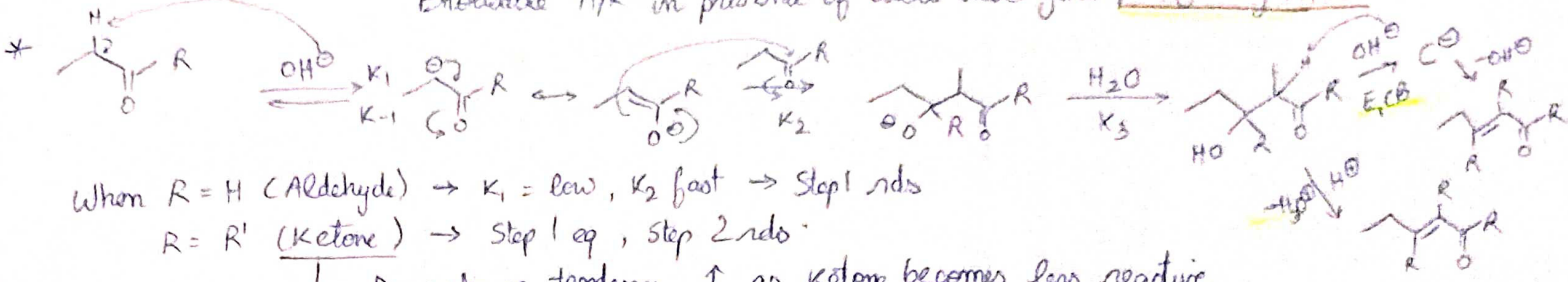
* CINE SUBSTITUTION (LG & substituting agent are at adjacent C)

* Nitro Benzene ω EWG @ para reacts ω KCN (aq) to give meta subs benzoic acid (cine substitution)



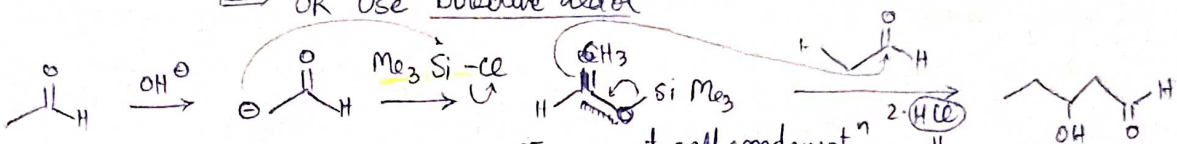
ALDOL CONDENSATION

Enolizable A/K in presence of dilute base gives β-hydroxy A/K



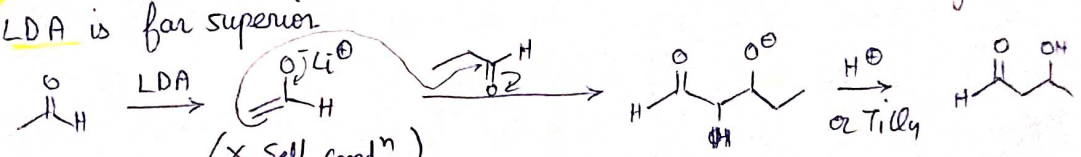
When R = H (Aldehyde) → K_1 = low, K_2 fast → Step 1 rds
R = R' (Ketone) → Step 1 eq, Step 2 rds.
↳ D-exchange tendency ↑ as ketone becomes less reactive

→ ISSUE – When both reactant aldehydes/K are enolizable (and different – same give Self cond^n)
⇒ Try to take one in excess as per desired product.
⇒ OR Use Directive aldol

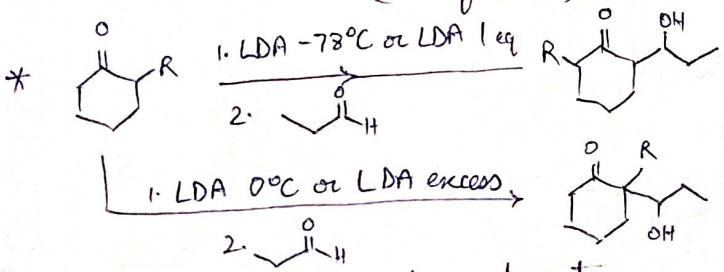


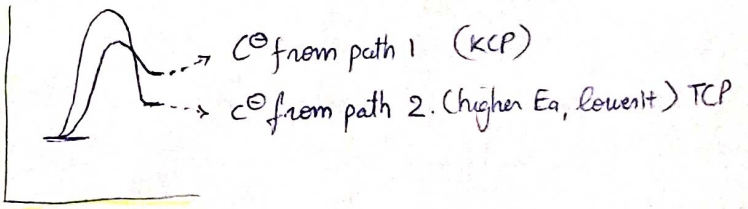
To prevent self condensat^n
dehydration ? → Use $TiCl_4$.

• LDA is far superior



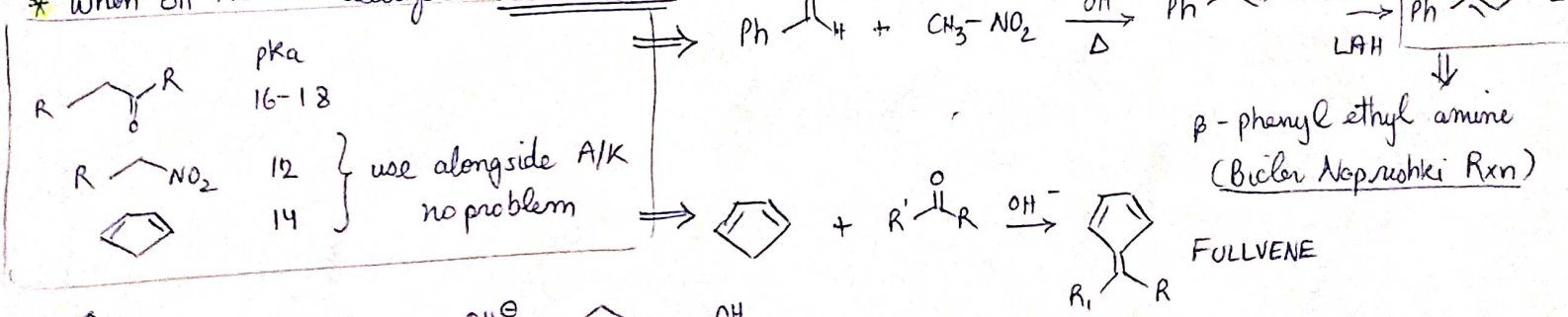
(✗ Self cond^n)





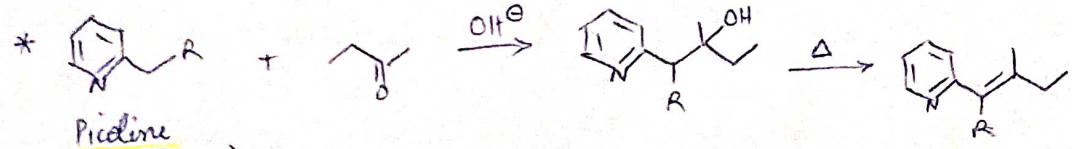
$C^\ominus$ from path 1 (KCP)
$C^\ominus$ from path 2. (Higher Ea, lower I.P) TCP

* When OH^-/Δ ⇒ always do condensation



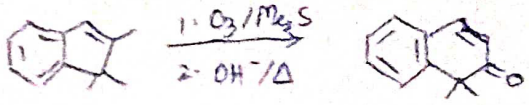
β-phenyl ethyl amine
(Bicler Napieralski Rxn)

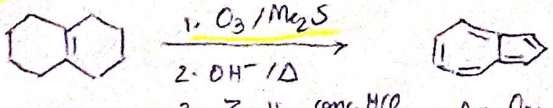
FULLVENE



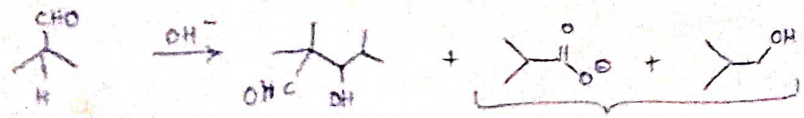
Picoline
(pKa ~ 16-18)
√A/K

→ Intramolecular aldol (VERY USEFUL) (6 > 5 > 7 m ring) ' Only ring size matters in product stability not the stab of $C^\ominus$.





Azulene

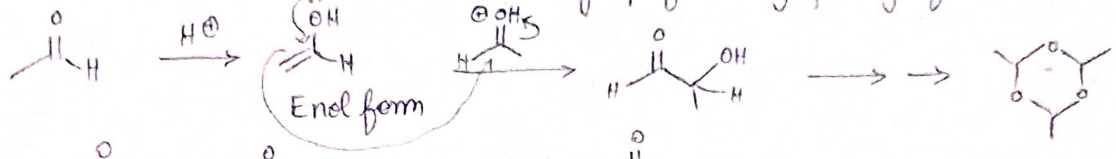


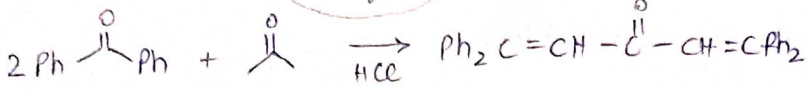
only 1 α-H

Cannizzaro

⇒ Aldol ✓ in acidic
Cannizaro ✗ in acidic
} Useful every where to control Cannizaro? NO b/c acidic medium means high dehydration + polymerisation tendency.

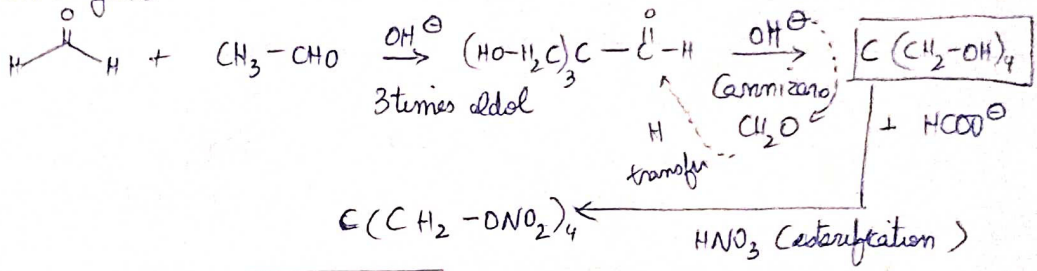
∴ always prefer ~~almy~~ only for 1 α-H and Phenyl Ketones.

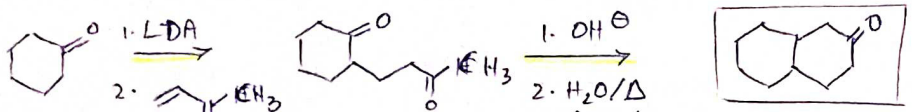




⇒ RETRO Aldol – simple Reverse gear

→ RING / Chain extension

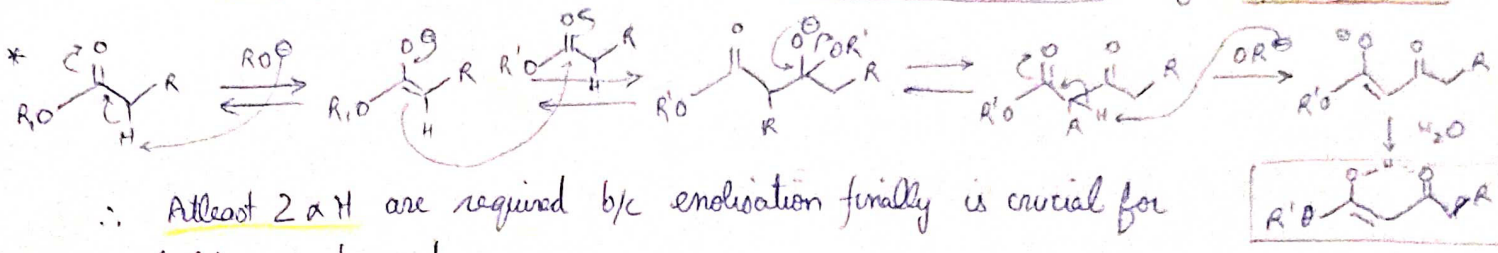




~~Enoyl~~
(methyl vinyl ketone)

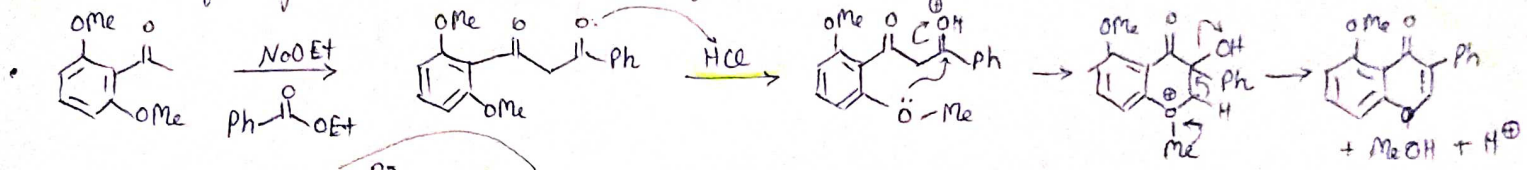
CLAISEN CONDENSATION → not $OH^{\ominus}$ b/c ketone loss reaction

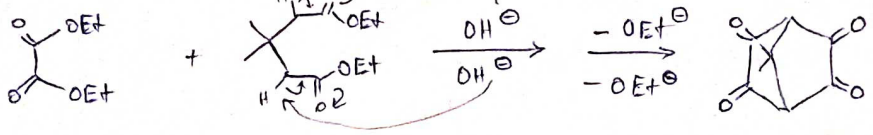
Ester w atleast 1 α H reacts with (sodium alkoxide base) to give β-keto ester



∴ Atleast 2 α H are required b/c enolisation finally is crucial for driving rxn forward.

But if only 1 α H present, use stronger base ~~Et^{+}~~ $Me_3CO^{\ominus}Na^{+}$

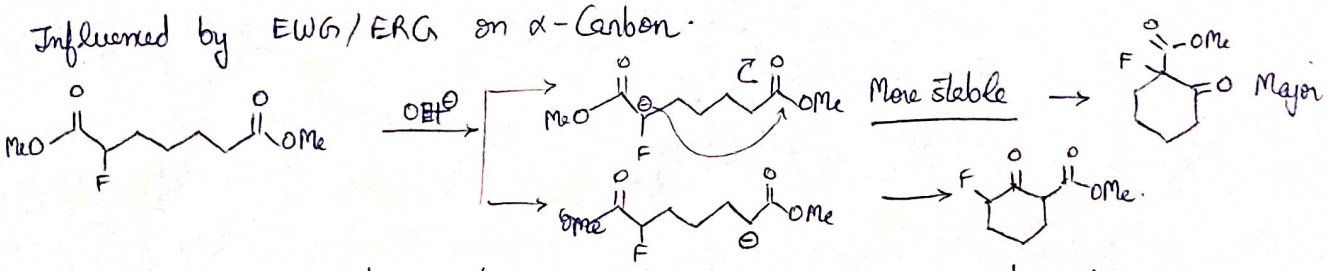




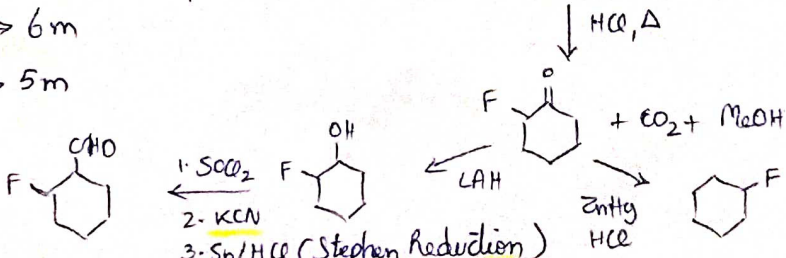
DIECKMANN CONDENSATION

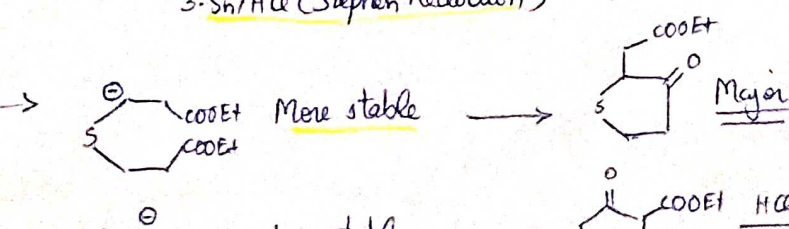
Intramolecular Claisen.

* Influenced by EWG/ERG on α-Carbon.



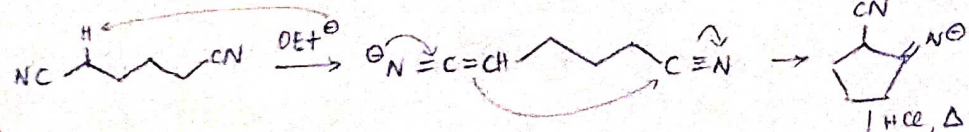
* Solvent effect < Aprotic → 6m
  Protic → 5m



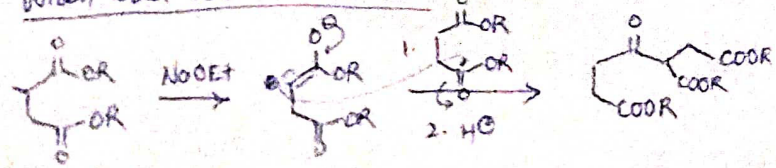


* Change in course

* Ziegler Condensation



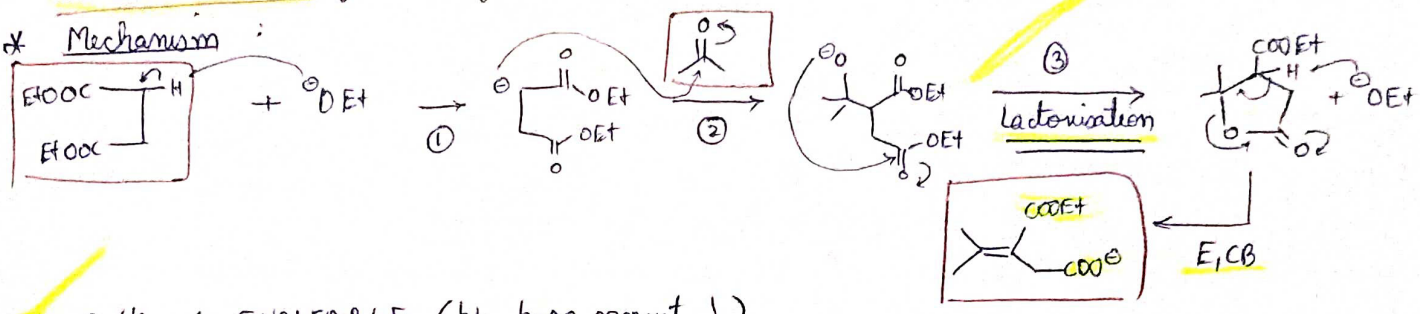
* When ester has < 6 Carbons



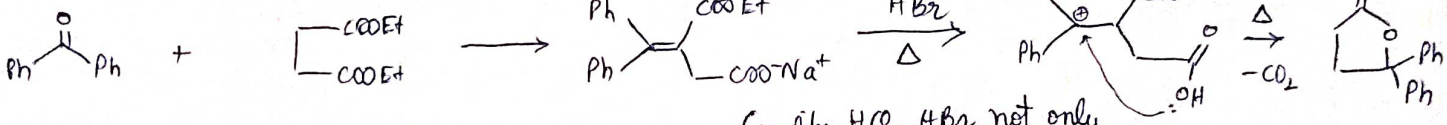
Stobbe Condensation

* Diethyl succinate reacts w carbonyl in presence of NaOEt, giving Carbethoxy β-γ unsaturated acid after acidification

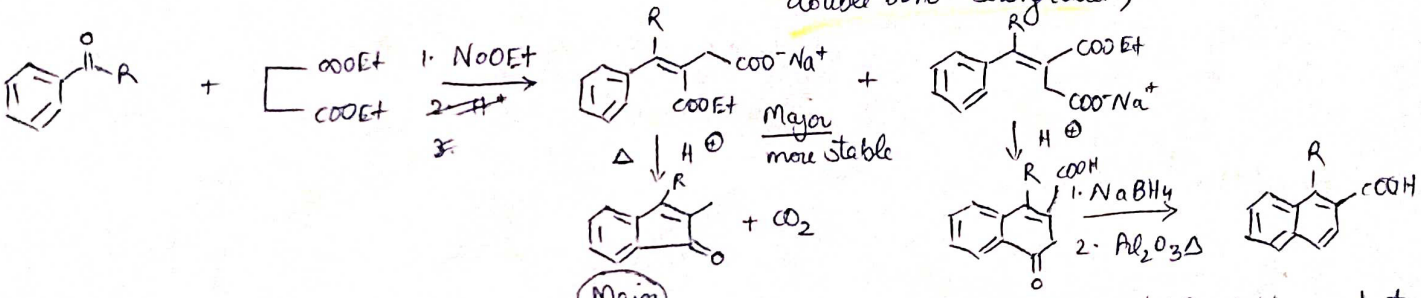
* Mechanism :



* A/K ≠ ENOLISABLE (b/c base present !)

* 

(Unlike HCl, HBr not only protonates but also attacks double bond - stronger acid)

- 

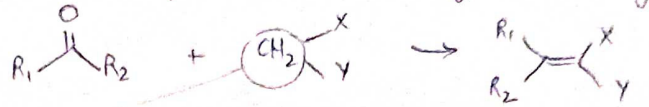
Major → if R = Bulky, ~~5m ring~~ unstable stobbe product

∴ ↳ gives 6m ring = major

KNOEVENAGEL C^N

* Carbonyl undergoes C^N ω active methylene in presence of base to give α-β unsaturated comp.

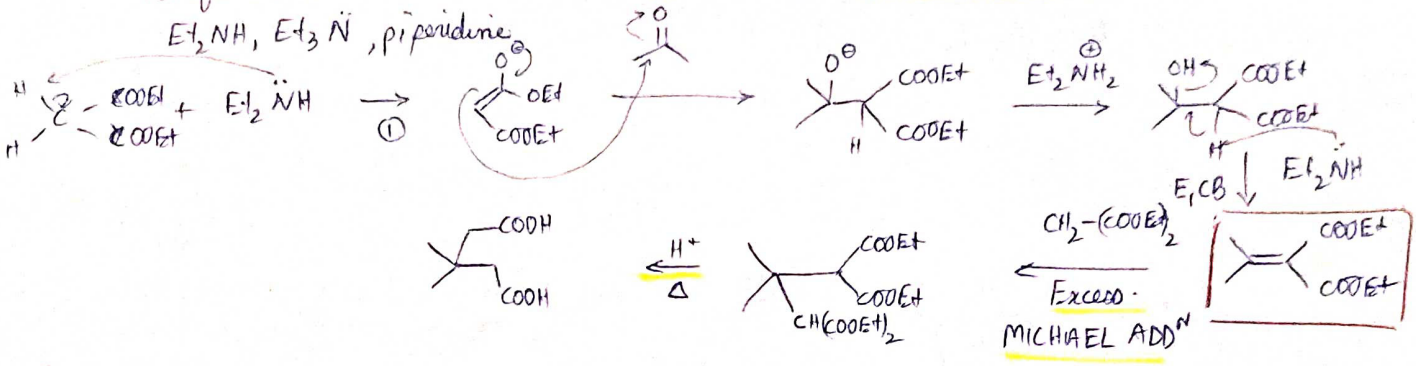
* Mechanism



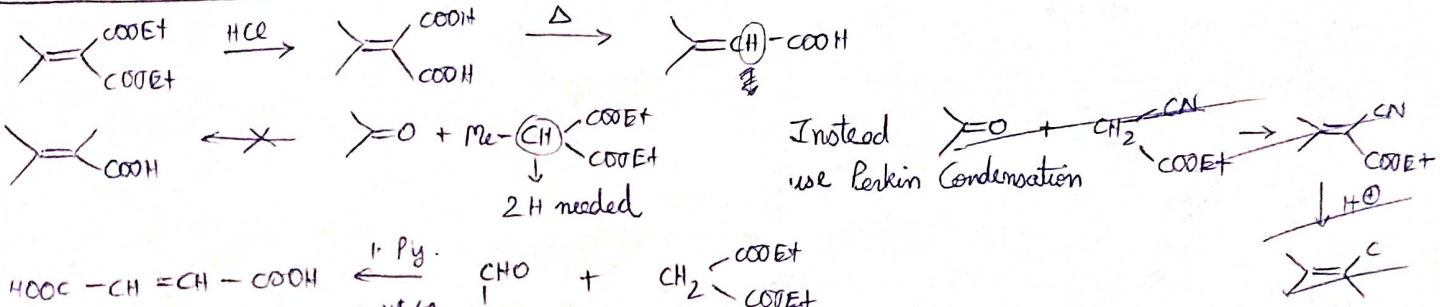
H is quite acidic ∴ weak base

Et_2NH, Et_3N, piperidine

X = CN / COOEt / $COCH_3$ / COOMe



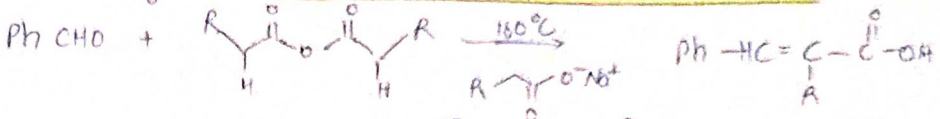
* α-β unsaturated acid



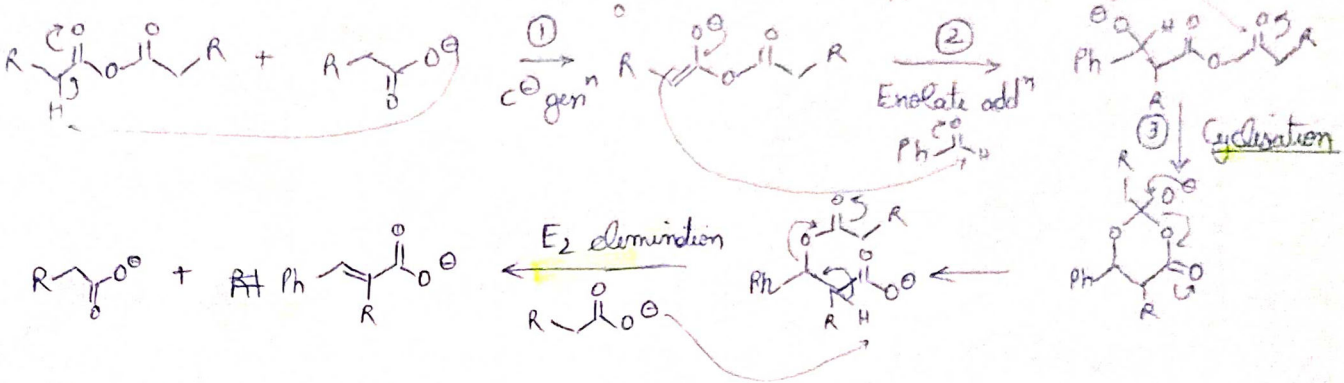
WOMEN ISSUES

PERKIN CN

Benzaldehyde + acid anhydride ω atleast 2 α H in presence of Na/K salt of acid corresponding to anhydride @ 160°C gives α-substituted α-β unsaturated acid

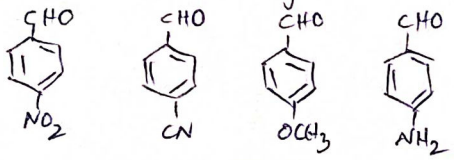


Mechanism

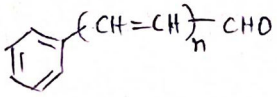
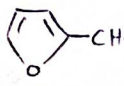


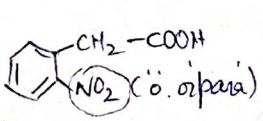
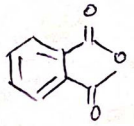
* ② is enolate addⁿ to Benzaldehyde

∴ EWG on Benzaldehyde ↑ its electrophilicity → lower rxn T.

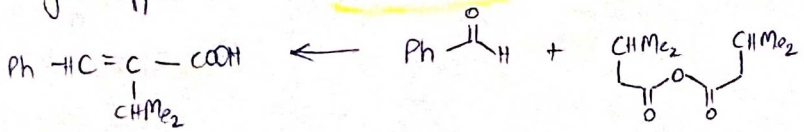


120°C 140°C 210°C No rxn

*   give rxn

  give rxn

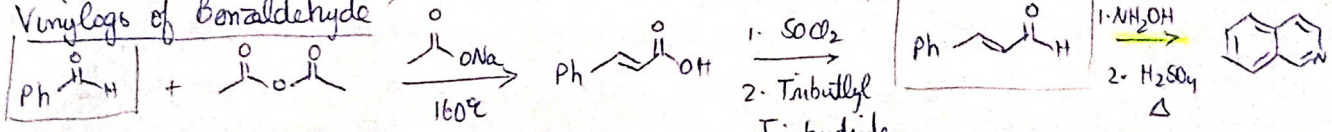
* Major application = α substituted αβ unsaturated acid.



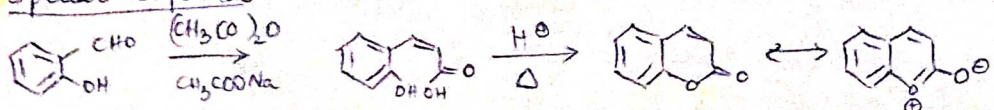
BUT  X from perkin

Use Knoevenagel Condⁿ (β-substituted)

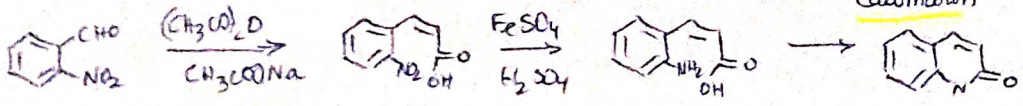
* Vinylogs of Benzaldehyde



* Special compounds



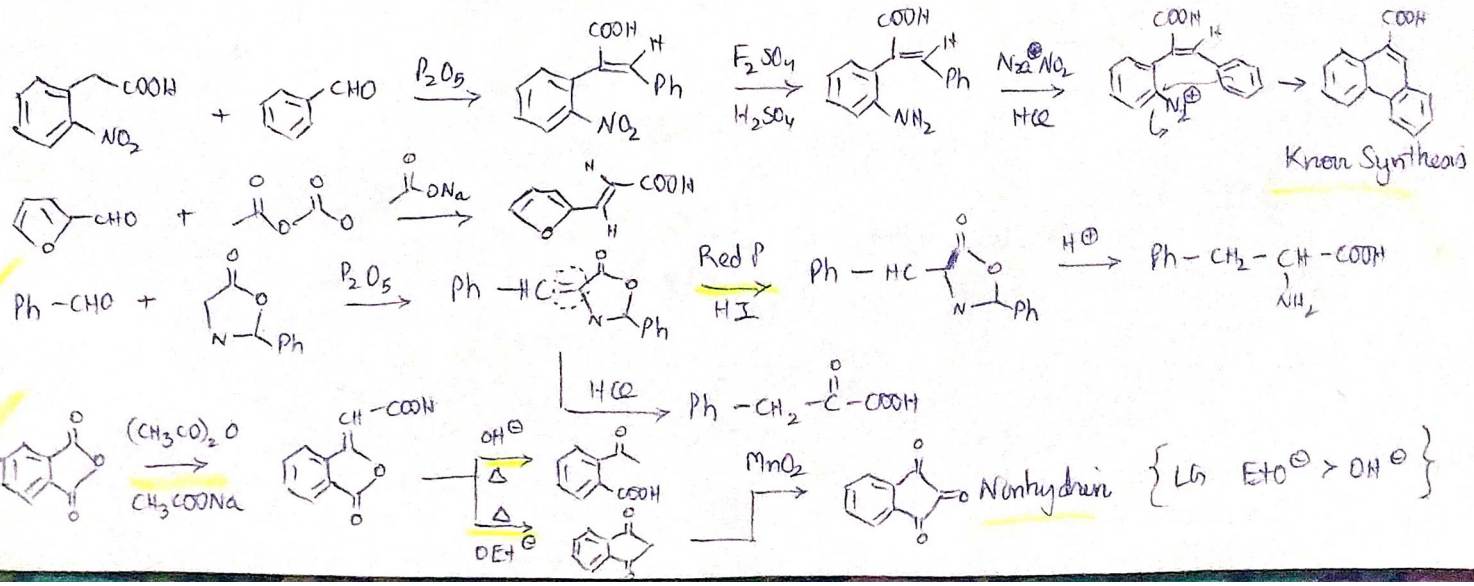
Coumarin



(X NH2 b/c X Perkin)

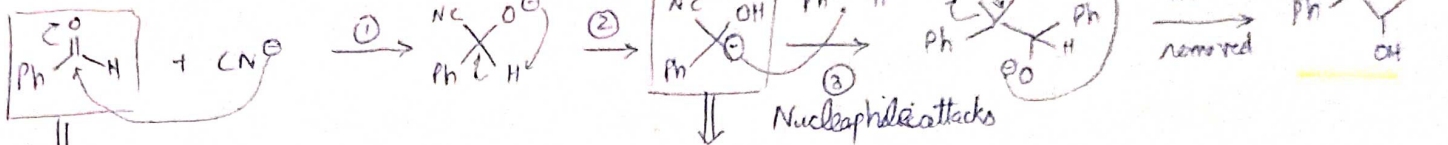
PTO

Cont ... Perkin


COOH
NO2
CHO
P2O5
Ph
F2SO4
H2SO4
NH2
NaNO2
HCl
N2
Knoer Syntheas
ONa
Ph-CHO
Red P
HI
H⊕
Ph-CH2-CH-COOH
NH2
HCl
Ph-CH2-C-COOH
(CH3CO)2O
CH3COONa
OH⊖
Δ
OEt⊖
MnO2
Ninhydrin
{LG EtO⊖ > OH⊖}

BENZOIN C^N

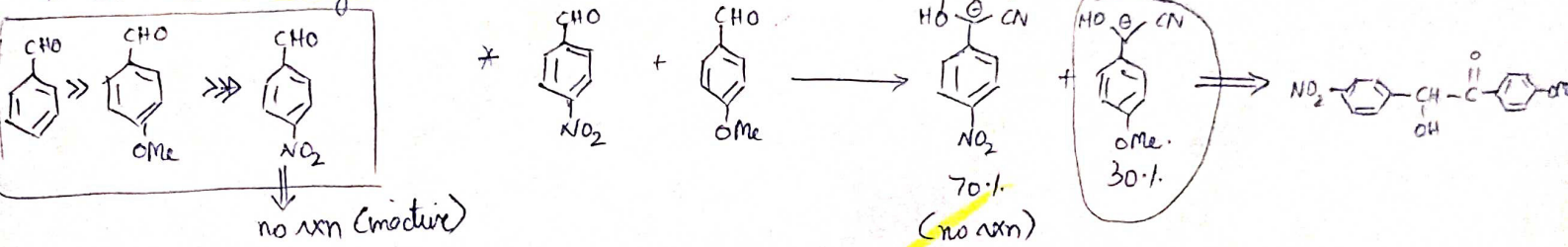
- Benzaldehyde + CN^- gives α-hydroxy di-aryl ketone (Benzoin)
  (Benzaldehyde: specific; CN^-: specific)
- Both ERGs & EWGs ↓ rxn rate



If ERG, its reactivity ↓

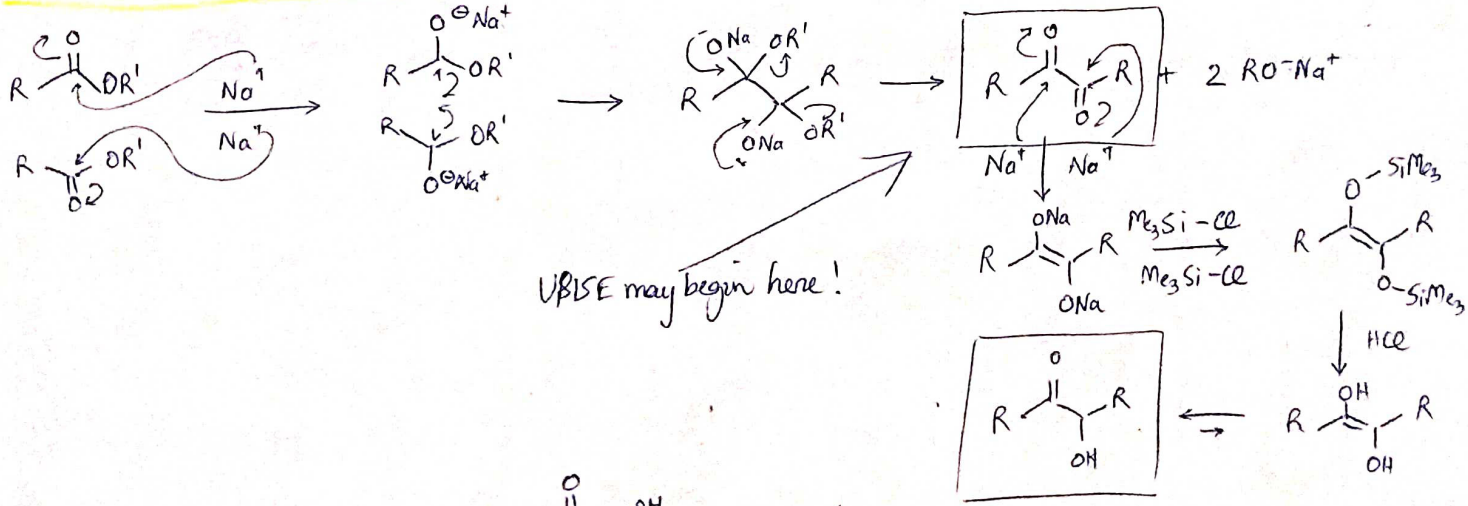
If EWG, it is so much stab that rxn ceases (it is already stab by -I of Ph & -M of CN)

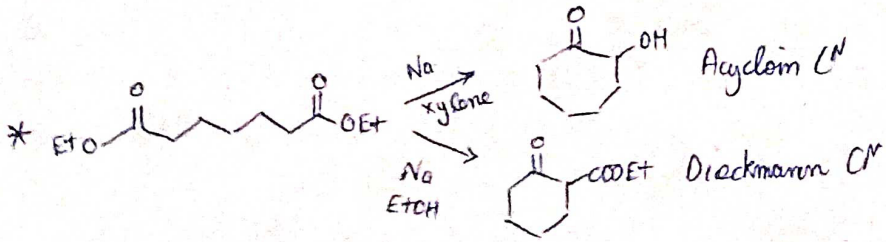
* CN^- acts as catalyst (moderate LG + stabilise $C^\ominus$ + stery $Nu^\ominus$)



ACYLOIN C^N

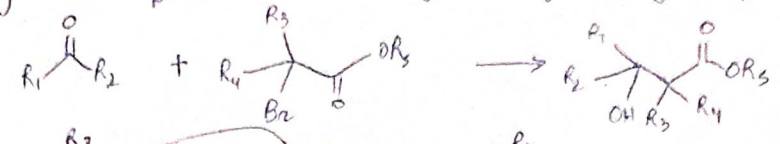
- Ester reacts w Na in hot xylene to give α-hydroxy ketone (Acyloin)



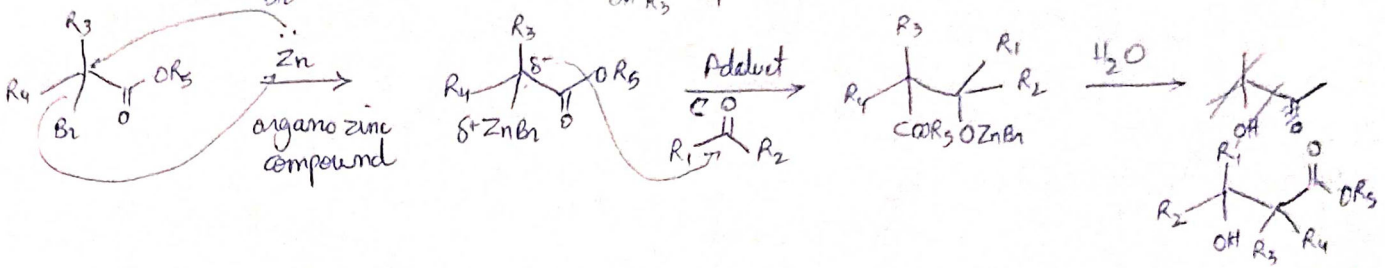
* 

REFORMATSKY RXN

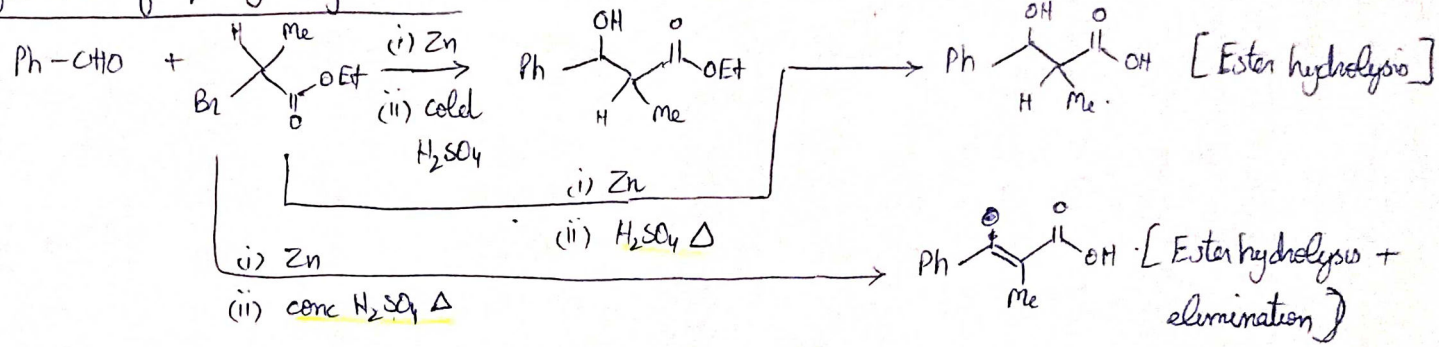
Carbonyl + α-bromo ester $\xrightarrow{Zn}$ after acidification gives β-hydroxy ester [If Mg used, Nu⁻ Carbon can attack even ester → multiple pdts]



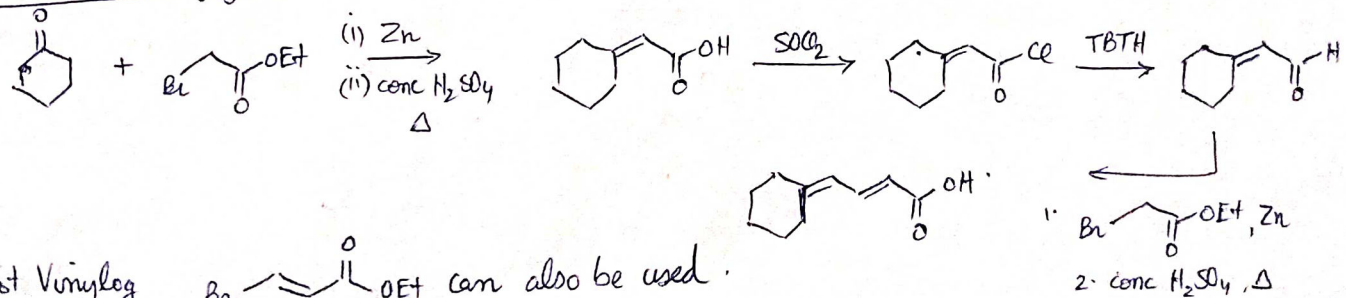
Mech:



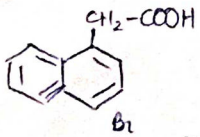
⇒ Synthesis of β-hydroxy ester



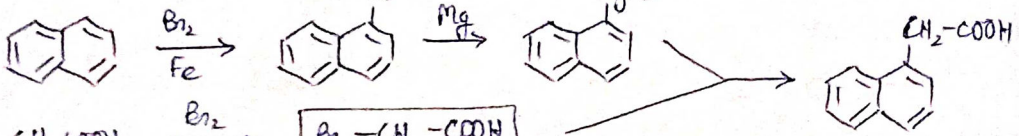
⇒ To increase conjugation



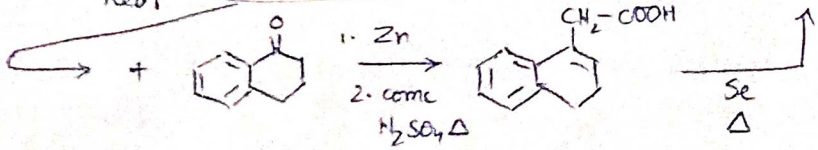
* Ist Vinylog can also be used.

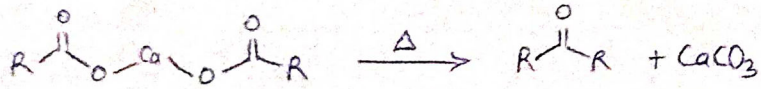
* CH_3-COOH → 

Method 1



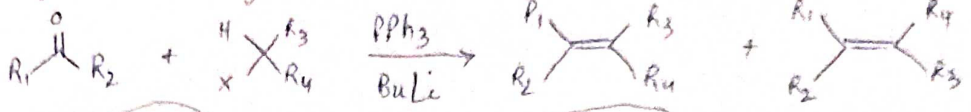
Method 2



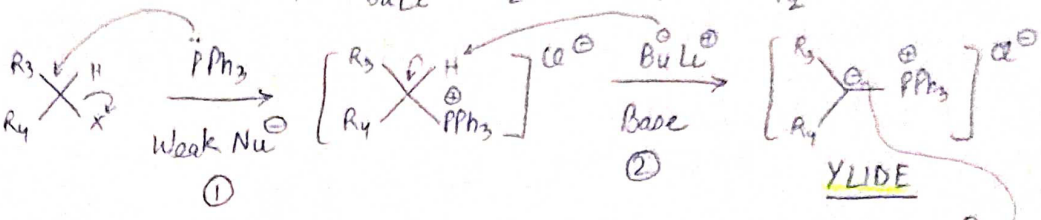
* Distillation of  $\xrightarrow{\Delta}$ $+ CaCO_3$

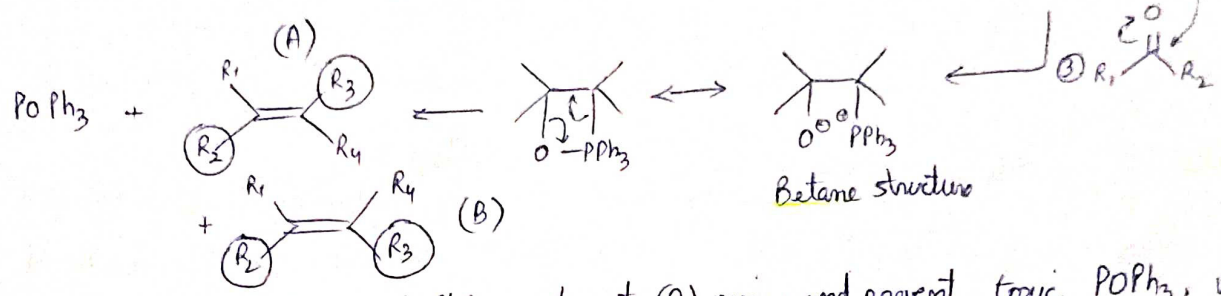
WITTIG RXN

* Carbonyl + alkyl halide having 1∝ H react in presence of PPh_3 and v. strong base to give Alkene



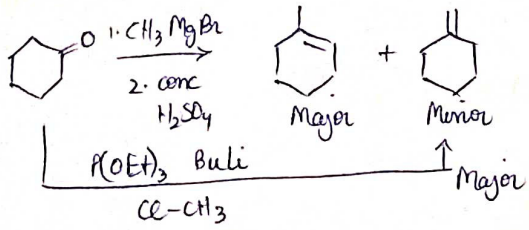
Mechanism

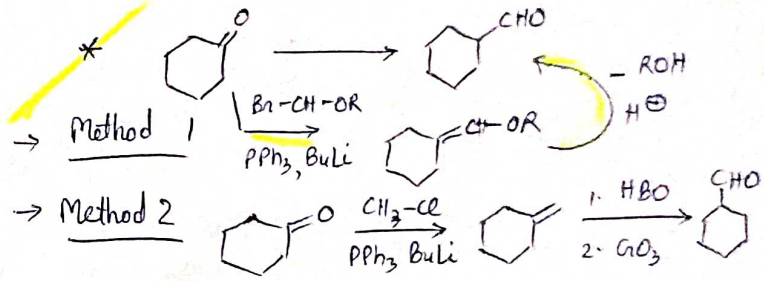




given R_2 & R_3 are bulkier, to get (A) major and prevent toxic $POPh_3$, use $P(OEt)_3$

* Introduction of DB at any location!

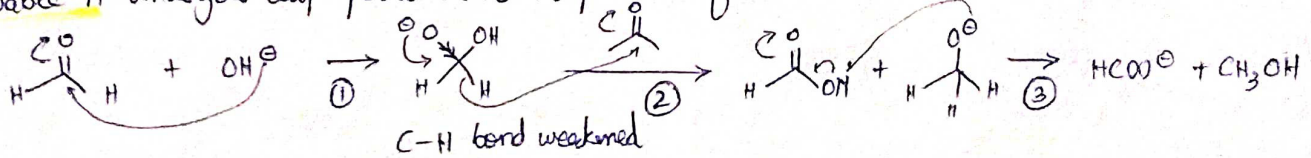




* Vinyl chloride $R-CHO + CH_2Cl_2 \xrightarrow[BuLi]{PPh_3} R-CH=CH-Cl$

CANNIZZARO RXN

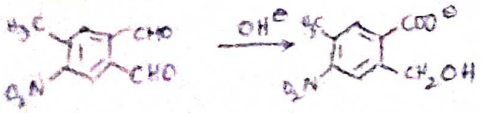
* Non enolisable A undergoes disproportionation in presence of OH^-
* Mechanism



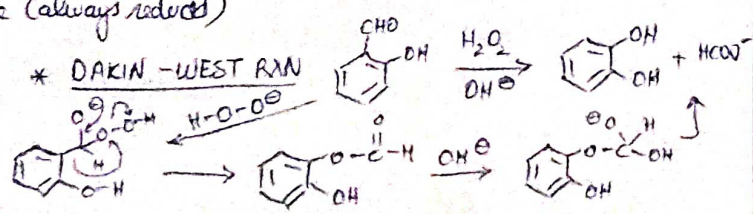
* Cross Cannizzaro $PhCHO + HCHO \xrightarrow{OH^\ominus} PhCH_2OH + HCOO^\ominus$ b/c ① → $OH^\ominus$ attacks on more electrophilic site.

$\xrightarrow{\times} PhCOO^\ominus + CH_3OH$

- Intramolecular Cannizzaro – even Ketone can participate (always reduced)

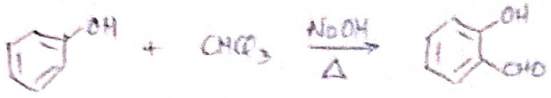


* DAKIN-WEST RXN



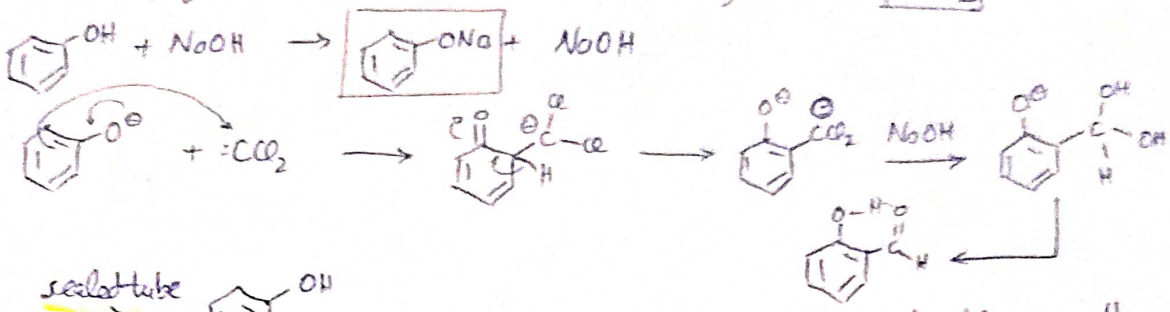
REIMAN – TIEMAN

* E^+ subs of a weak E^+ on a v- activated Benzene ring.



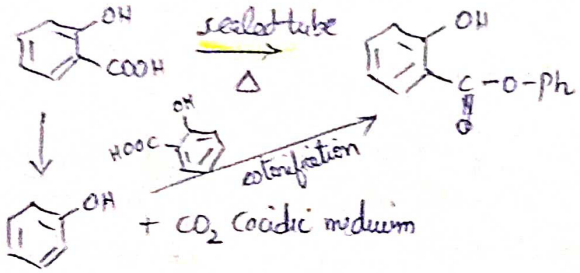
Salicylaldehyde

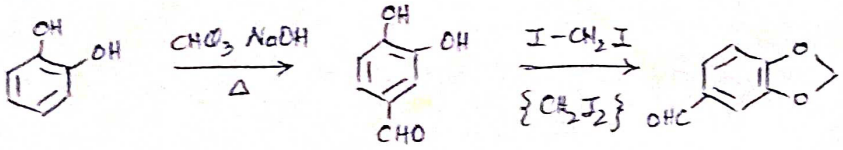
* Mechanism Formation of Carbene $H-CCl_3 + NaOH \rightarrow CCl_3^{\ominus}Na^{\oplus} \rightarrow \boxed{:CCl_2} + NaCl$



Hydrogen bonding ∴ ortho major

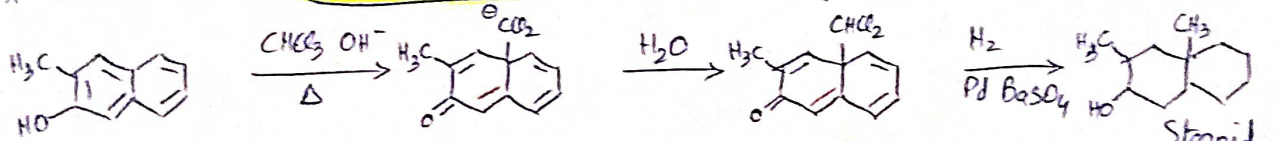
* If ortho substituted, para major.





Clove Oil

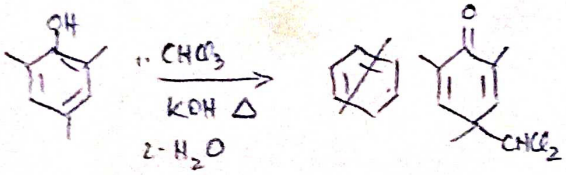
* Substitution on RING JUNCTION QUITE INERT)

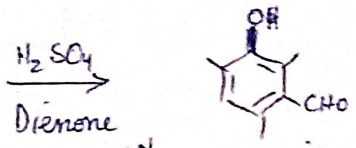


Steroid

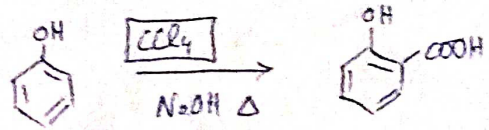
(X OH^- subs b/c SH)

* When both 'o' & 'p' blocked





Looks like meta substitution

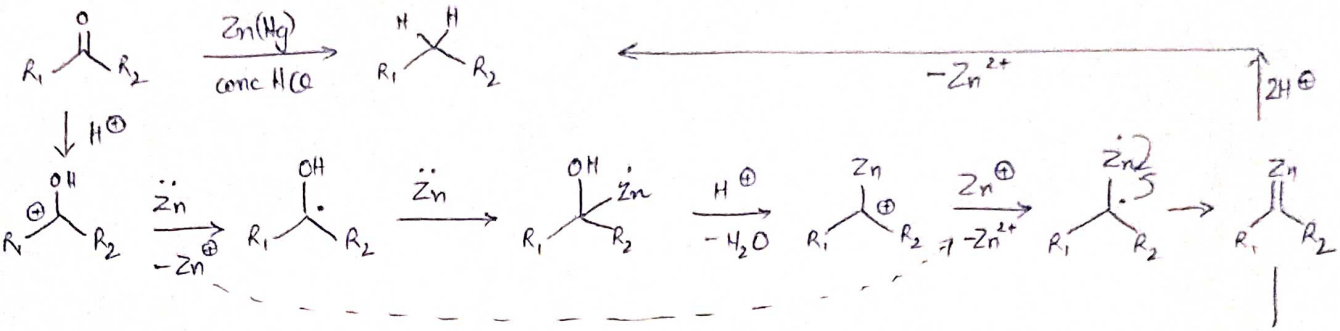
* 

Simple Nu addition

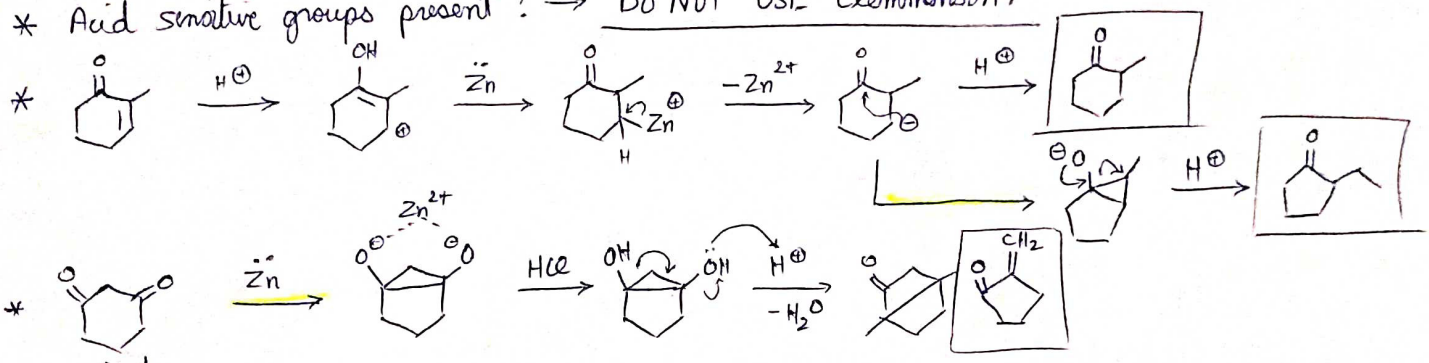
Not Reiman Tiemann

CLEMMENSON REDUCTION

Complete reduction of carbonyl compound into hydrocarbon in presence of Amalgamated Zn, conc HCl.

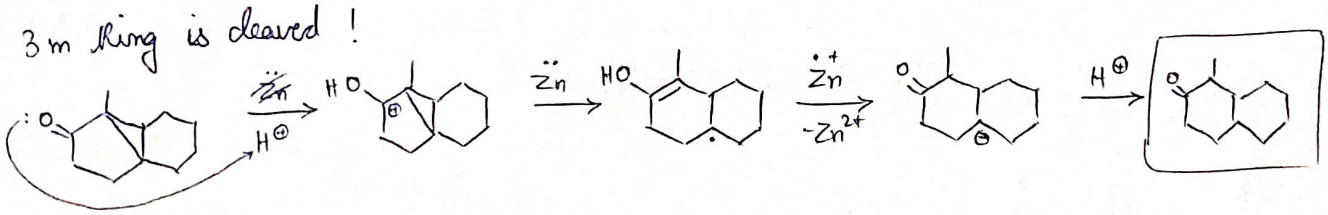


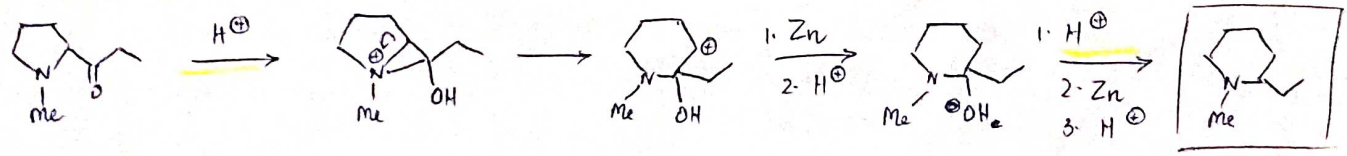
* Acid sensitive groups present ? → DO NOT USE Clemmenson!



β-diketone

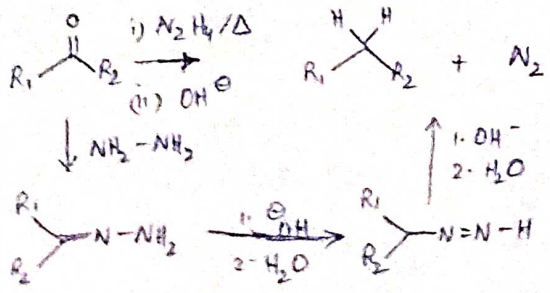
- 3m Ring is cleaved !



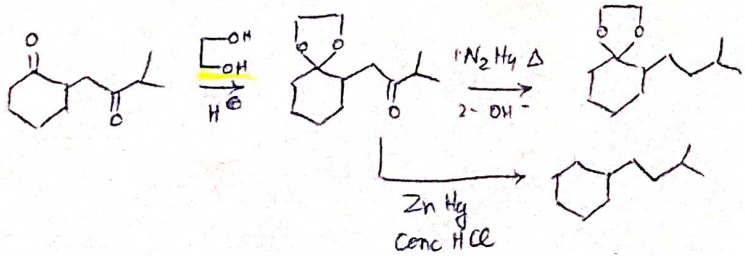


WOLF KISHNER REDUCTION

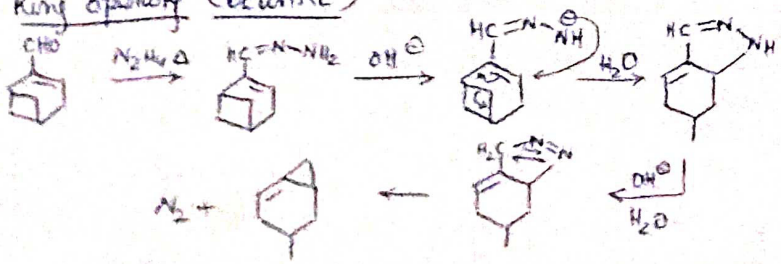
* Carbonyl + hydrazine followed by basic medium gives hydrocarbon with N_2 gas.



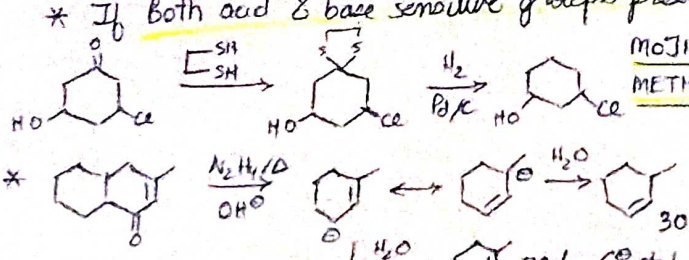
* In 2nd step if in Na is used, single step rxn.



* Ring opening (BEWARE)



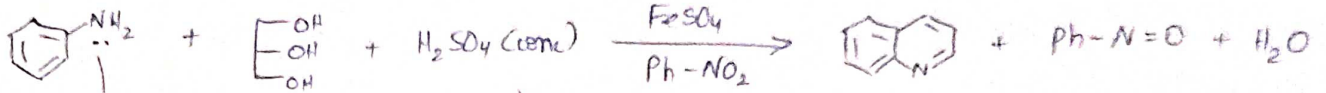
* If Both acid & base sensitive groups present

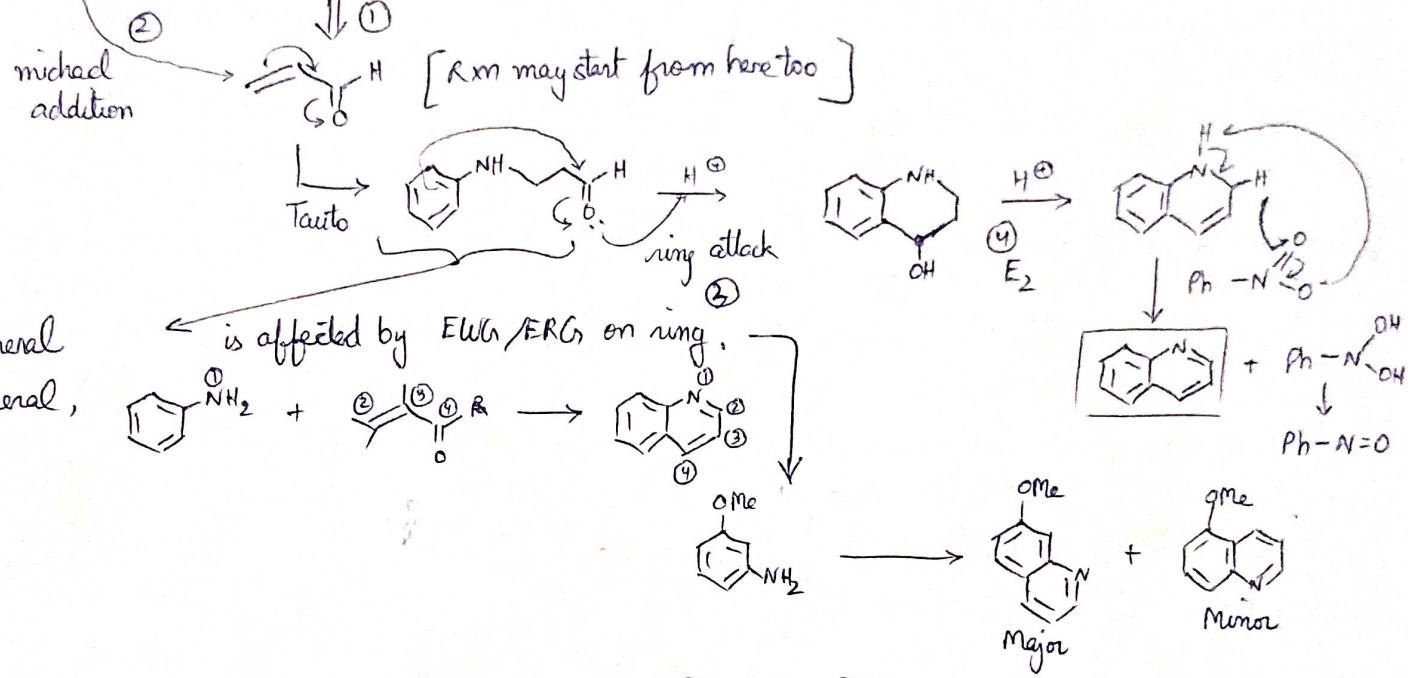


SKRAUP SYNTHESIS

Quinoline

Aniline + glycerol in conc H_2SO_4 & nitrobenzene solvent ⇒ $FeSO_4$ gives Quinoline (70–75% yield)



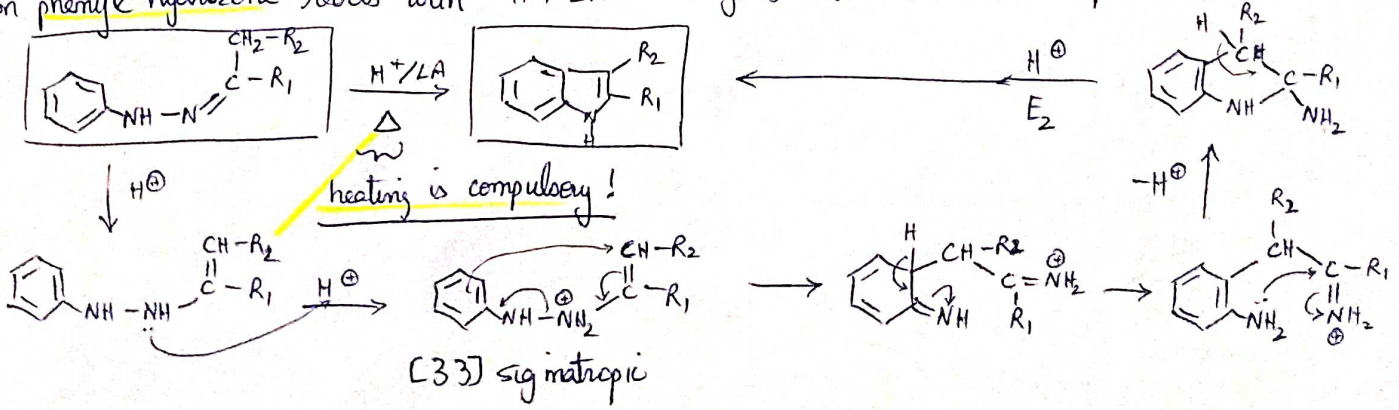


* In general is affected by EWG/ERG on ring.
* In general,

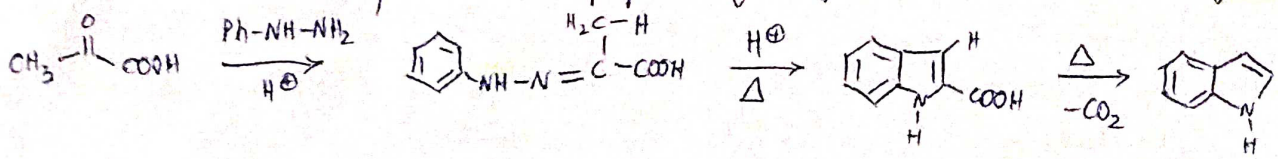
FISHER - INDOLE SYNTHESIS

Substituted Indole.

- When phenyl hydrozone of Carbonyl comp. reacts with H^+/LA – it gives substituted indole provided it has 2α-H.



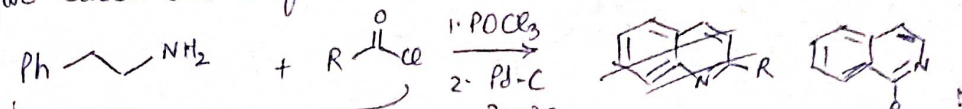
- HOWEVER, Indole directly cannot be prepared from fisher indole. We use Pyruvic acid.

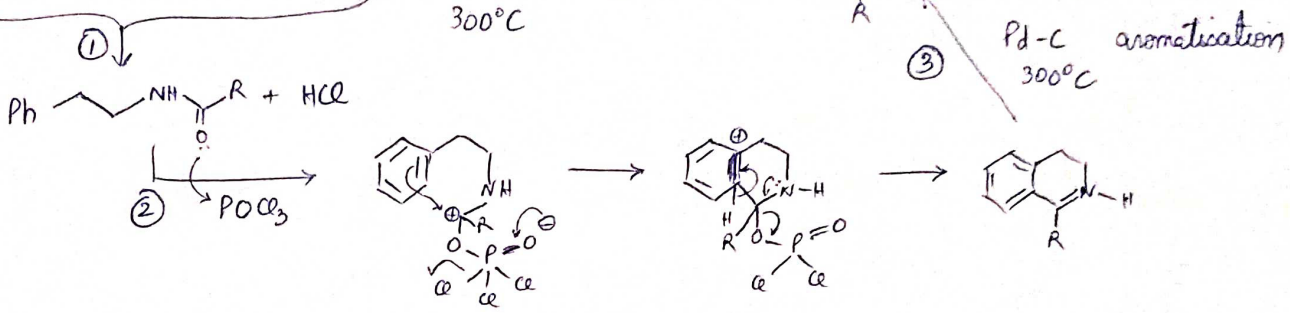


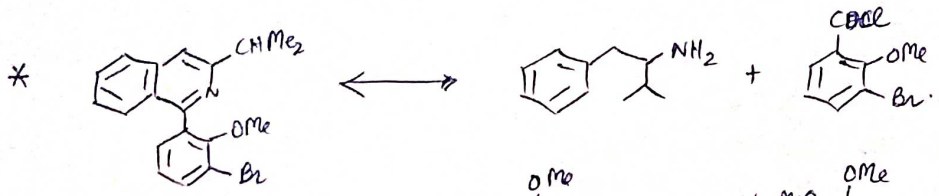
BISCHLER - NAPIERALSKI RXN

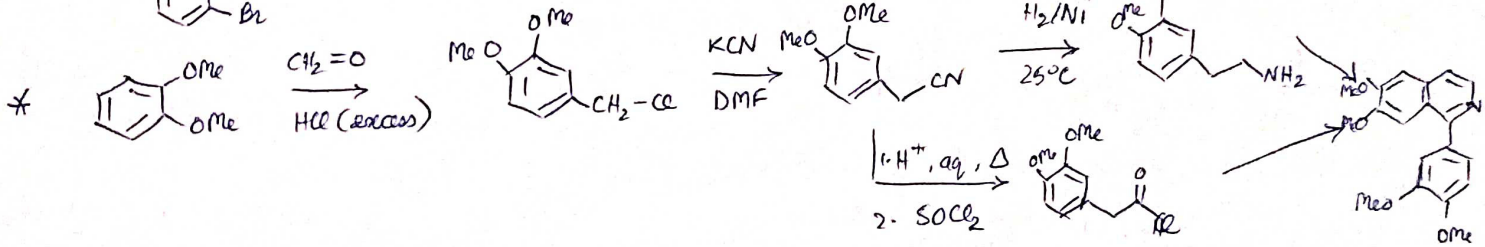
Isoquinoline

β-phenyl ethyl amine reacts w acid chloride in presence of $POCl_3$ followed by aromatisation to give substituted isoquinoline





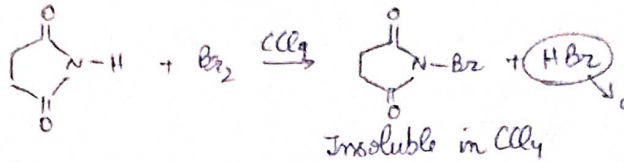




REAGENTS

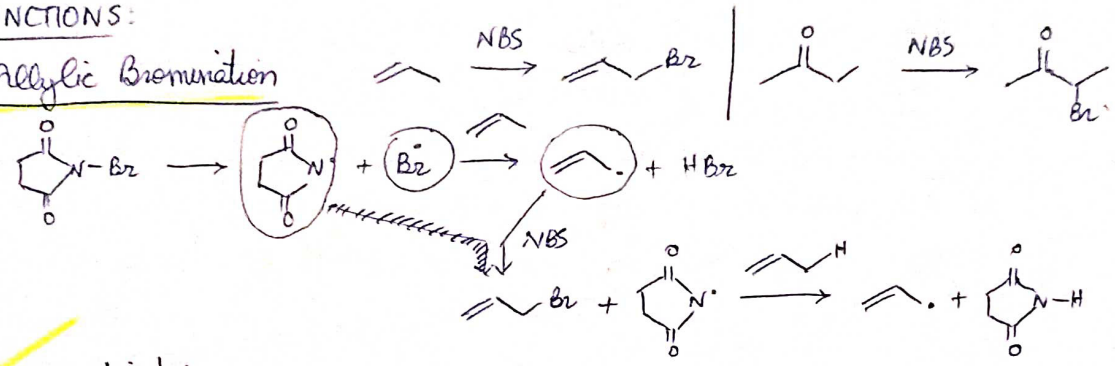
(I) N-bromo Succinimide (NBS)

- **Preparation**

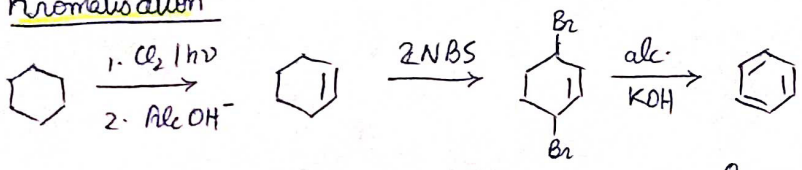


- **FUNCTIONS:**

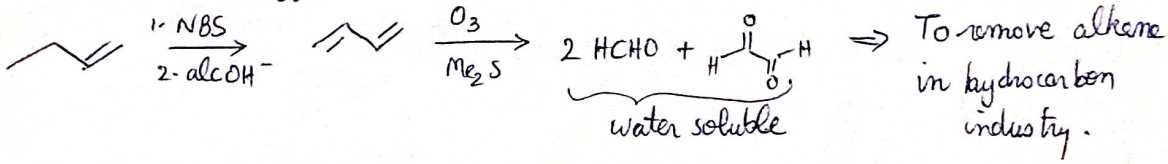
① **Allylic Bromination**



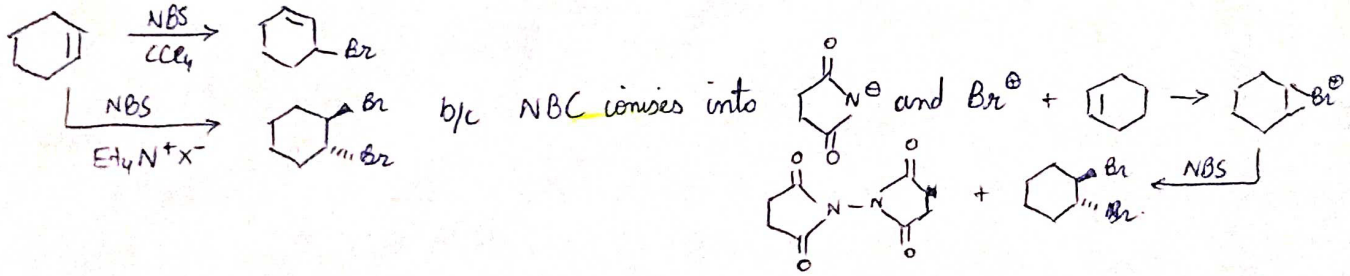
② **Aromatisation**



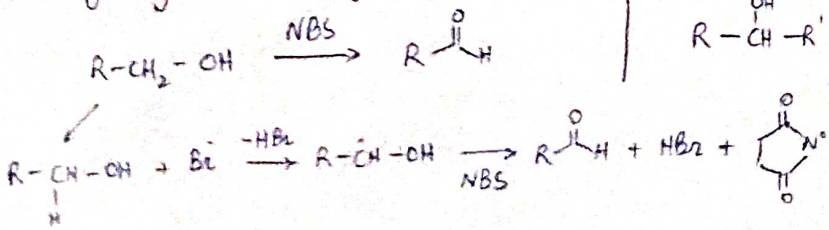
③ **Fragmentation**



④ **Addition in polar solvent**



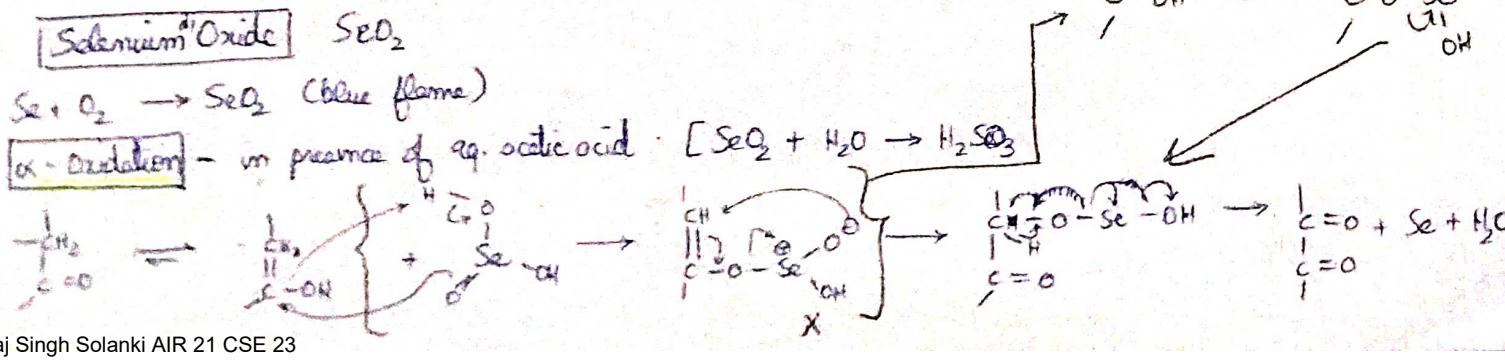
* If allylic or benzylic position is absent, secondary alc as an oxidant is utilised.



(II) Selenium Oxide SeO_2

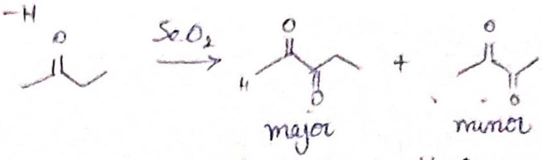
* $Se + O_2 \rightarrow SeO_2$ (Blue flame)

* **α - Oxidation** - in presence of aq. acetic acid [$SeO_2 + H_2O \rightarrow H_2SeO_3$]

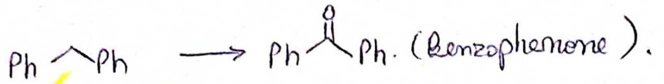


Eg: • $CH_3-CHO \rightarrow H-\overset{O}{\overset{\|}{C}}-\overset{O}{\overset{\|}{C}}-H$

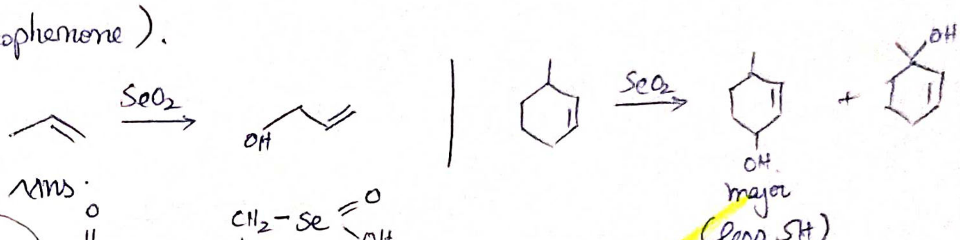
• Since Reactivity of 1° > 2°



• If carbonyl other than A/K, then only activated methylene

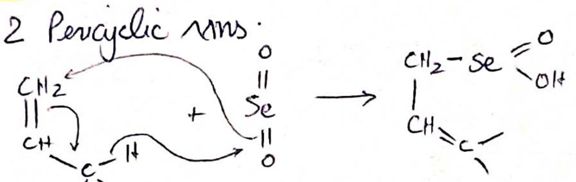


* Allylic hydroxylation

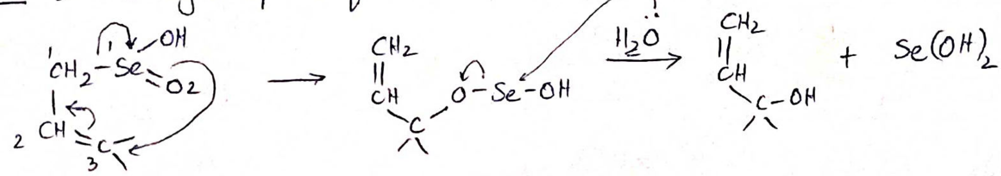


Mechanism involves 2 Pericyclic rxns.

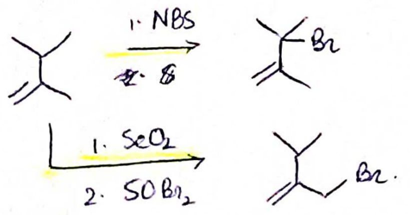
Step-1 Ene-Rxn



Step-2 [2,3] sigmatropic shift



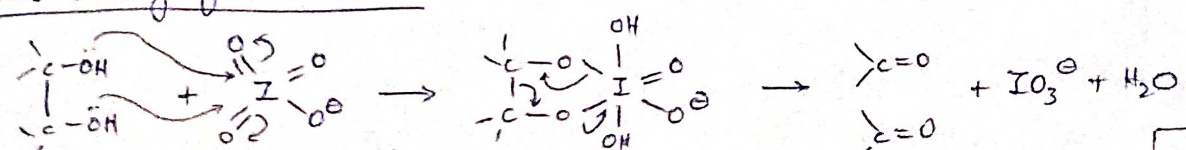
*

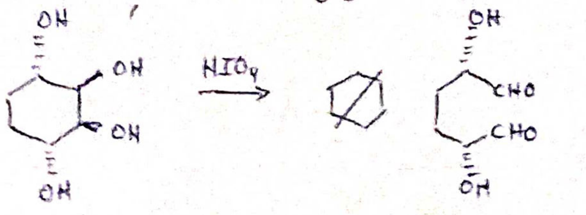


(III) HIO₄ PERIODIC ACID

* $I_2 + N_2O_5 \rightarrow I_2O_5 \xrightarrow{H_2O} HIO_4 \cdot 2H_2O$

* Oxidative cleavage of Vicinal diol

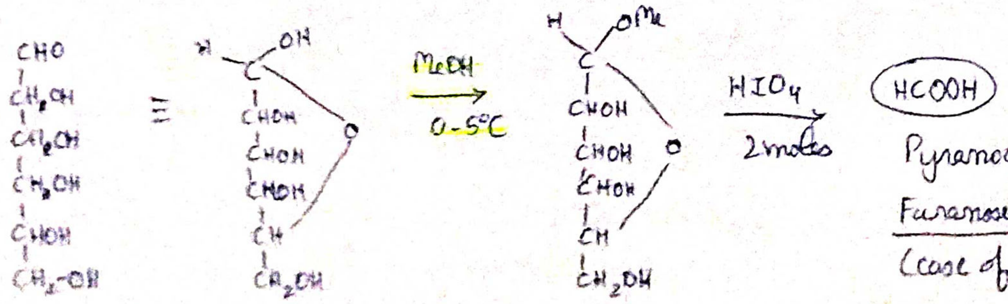




Dihedral angle matters b/c 5 m ring.

FRUCTOSE	
CH_2-OH $C=O$ CHOH CHOH CHOH CH_2OH	needs only 1 mol HIO_4

• Glucose



Pyranose Ring gives formic acid

Furanose ring gives formaldehyde (case of fructose)

LEAD TETRAACETATE

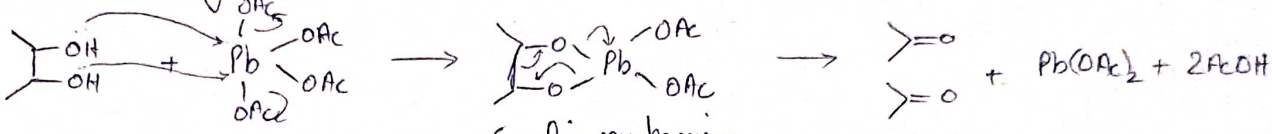
* $Pb_3O_4 + 8CH_3COOH \rightarrow Pb(OAc)_4 + 2\,Pb(OAc)_2 + 4H_2O$
(Red lead)

$Pb(OAc)_4$ ⇓ v-good OA b/c +4 highly unstab.

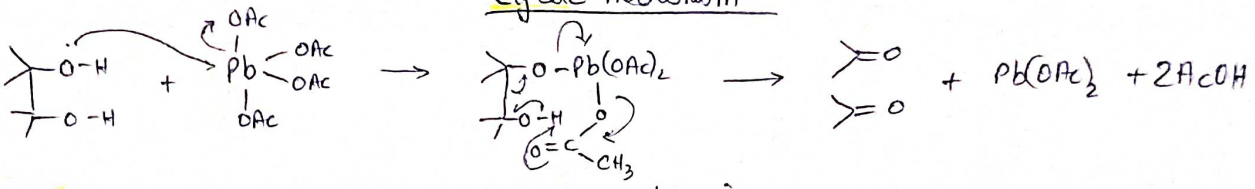
$Pb(OAc)_4 \rightarrow Pb(OAc)_2 + 2AcO^{\cdot}$ — Acetoxydation

$AcO^{\cdot} \rightarrow CH_3^{\cdot} + CO_2$ — Methylation.

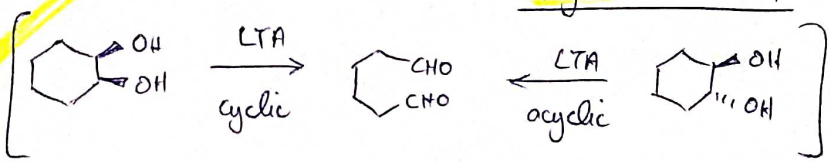
① Oxidative cleavage

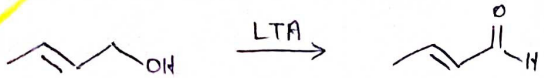


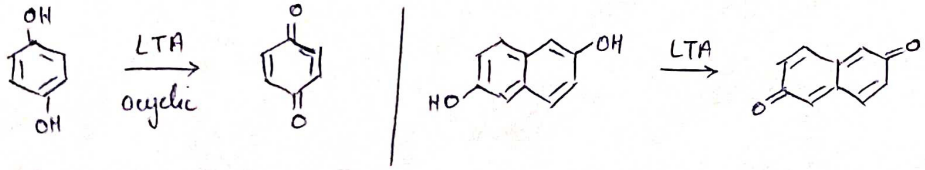
Cyclic mechanism



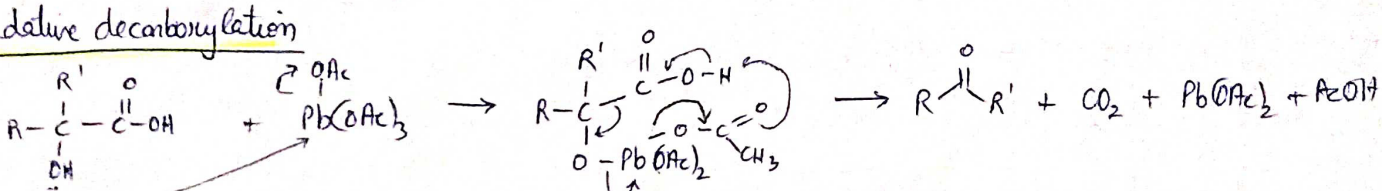
Acyclic mechanism

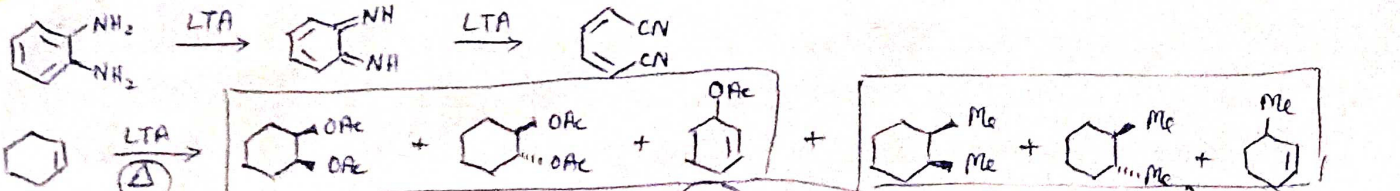


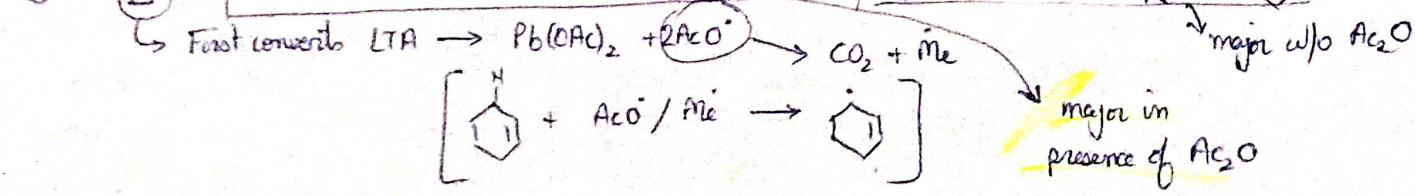
* 
Alcohol to A/K

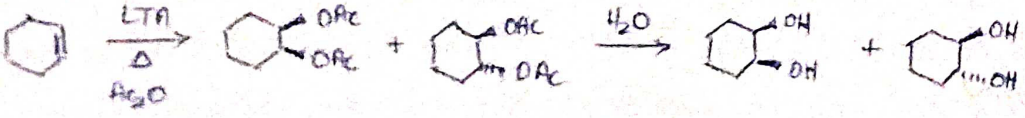
* 

② * Oxidative decarboxylation







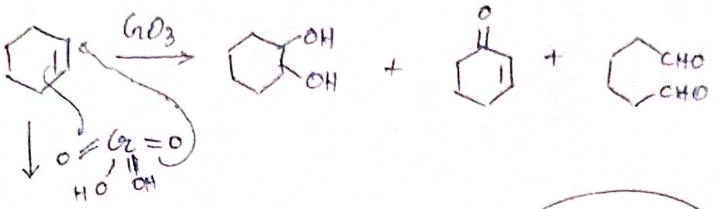


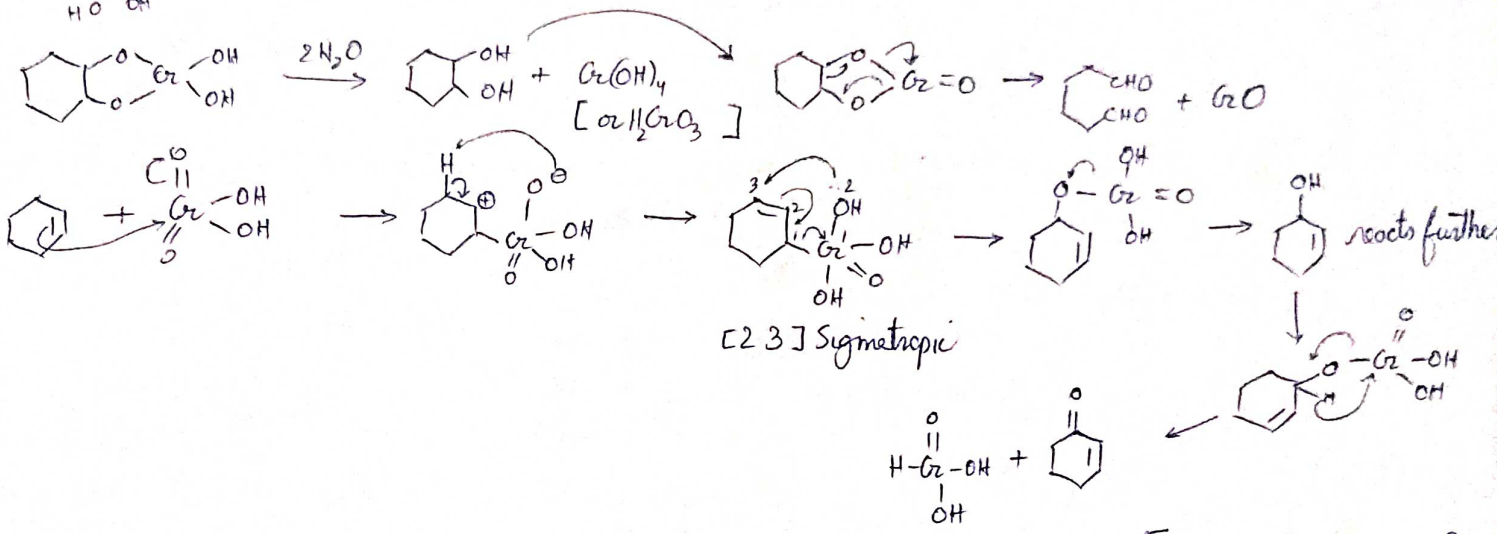
CHROMIUM TRIOXIDE

$Cr(VI)$ = strong OA

$CrO_3 + H_2SO_4(conc) = H_2CrO_4$

Chromic acid (unselective)





- However, it is selective for alkyne

$$R-C\equiv C-R' \xrightarrow[CrO_3]{} R-\underset{\underset{O}{\|}}{C}-\underset{\underset{OH}{|}}{C}-R' \longrightarrow R-\underset{\underset{O}{\|}}{C}-\underset{\underset{O}{\|}}{C}-R' + H_2CrO_2$$

No cleavage.

$HC\equiv CH + H_2CrO_4 \rightarrow$ (oxalic acid) $\xrightarrow{KMnO_4}$ COOH / COOH

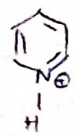
- Primary alcohol $R-CH_2-OH \longrightarrow R-CHO \longrightarrow \boxed{RCOOH}$

⇒ To introduce selectivity, use ① JONES Reagent [alcohol to only A/K]

$CrO_3 + (dil\ H_2SO_4) + CH_2Cl_2$ (solvent)

↓ Oxidising tendency.

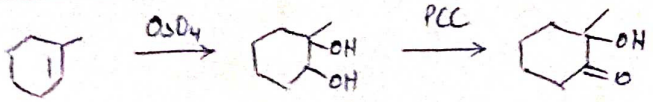
② Use Pyridinium Chlorochromate



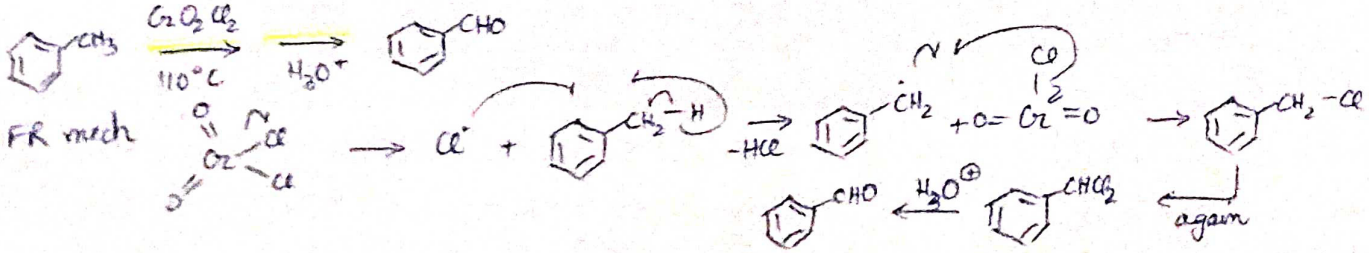
CrO_3Cl [aldehyde ~~to K~~]

alcohol to

* While both PCC & Jones can oxidise 1° & 2°, preferably Jones does 2° & PCC (bulky) does 1°.



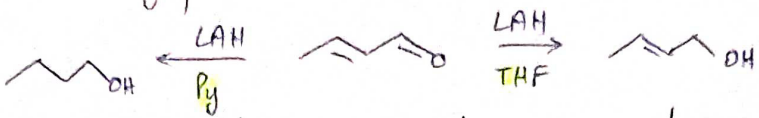
* ETARD RXN



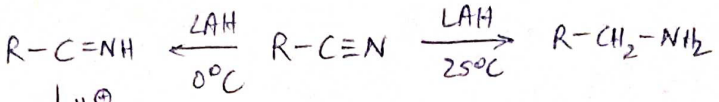
Reducing Agents

① LAH all except RX, ROH, ROR', DB, TB

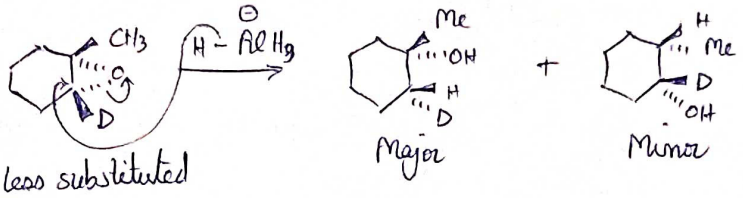
↳ Highly reactive, less selective



conjugated in presence of Py can undergo michael attack b/c Py can stab 



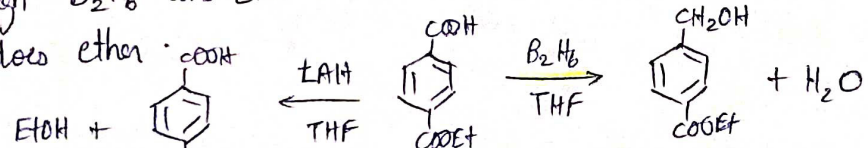
- Epoxide –

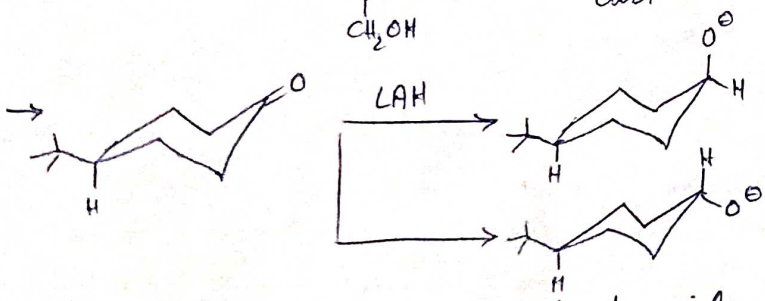


H attacks less substituted

② NaBH4 – only R-CHO, R-COR, RCOCl

→ Although B_2H_6 and LAH both can reduce acid & ether, preferably B_2H_6 does acid & LAH does ether.





Major b/c $O^{\ominus}$ less SH.

BUT when bulky subs present at axial position, H attacks equatorial.