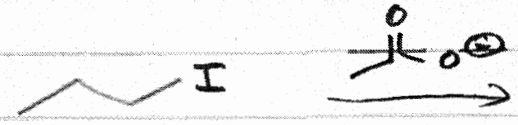
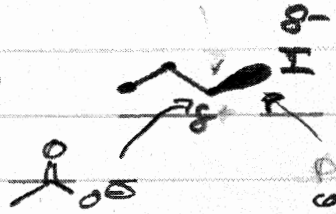
Ch 9-3

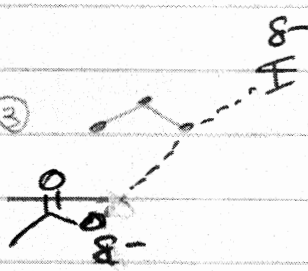
S_N2 reactions



① What is the nucleophile? 

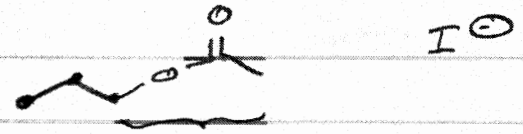
② Where will this nucleophile attack?



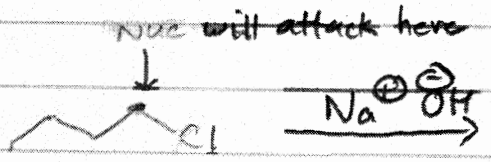
③ 

Account for carbons!

There are 3 C and the leaving group is $I^{\ominus}$

④ 

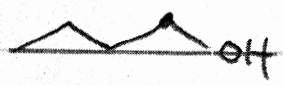
Nucleophile replaces 'I'



① What is the nucleophile? $^{\ominus}OH$

② Where will Nuc attack? (see arrowed C above)

③ Account for all atoms in structure, and do substⁿ.



Ch 9-4

S_N2 Rxns

① What makes a good nucleophile?

Localized Negative charge – not affected by resonance

Nuc:⊖

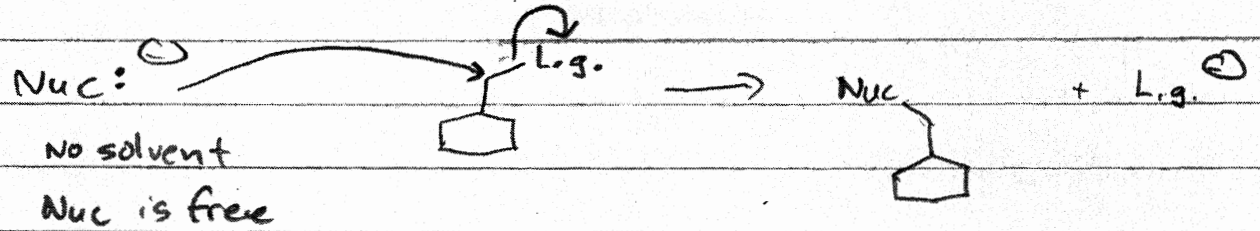
Good nucleophiles	
I^- Br^- Cl^-	HS^- HO^- HO^- $^-:N{\equiv}C:$ RS^- RO^- RO^-

NOTICE (−) charges

redrawn for clarity.

② How does solvent affect Nucleophilic Rxn rate in S_N2?

ⓐ Solvents that can H-bond to Nuc:⊖ will hinder/slow ability of Nuc to attack!



No solvent

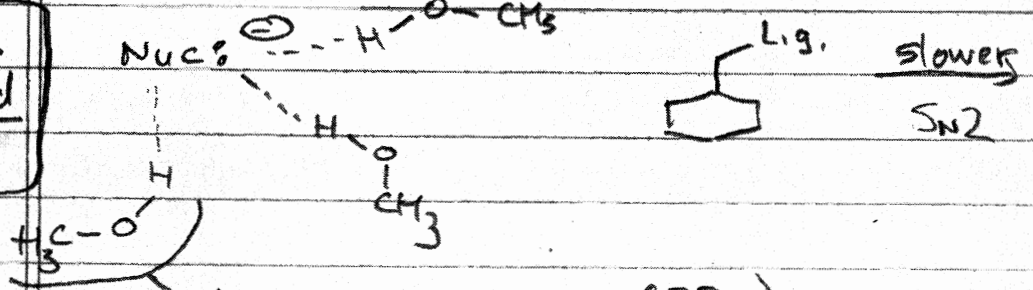
Nuc is free to attack

(PPS)

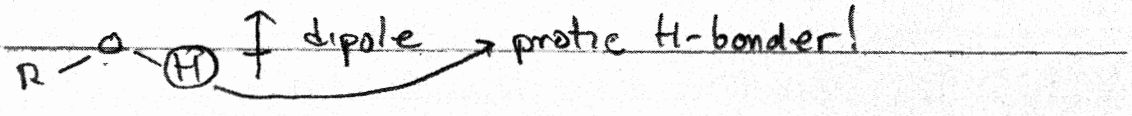
A polar protic solvent, can H-bond w/ Nuc:⊖

∴ S_N2 rxn is slowed down

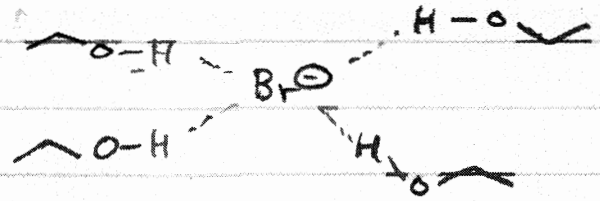
Nuc is blocked by PPS



polar protic solvent (PPS)



Ch 9-5



a PPS stabilizes (−) chrg of Nucleophile making it less likely to attack the δ+ of a polar covalent bond attached to L.g.

PPS (Slows S_N2 attack since rate is dependent on [Nuc:⊖])

(b) S_N2 reactions prefer polar Aprotic Solvent

non H-bonding

PPS

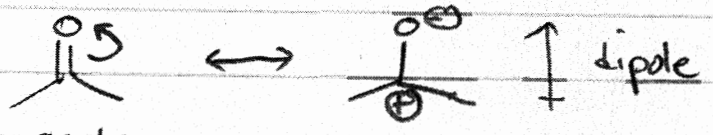
Protic solvents	Polar aprotic solvents
Water, Methanol, Ethanol, Ammonia, Acetic acid	Acetone, Dimethylformamide (DMF), Hexamethylphosphoramide (HMPA), Dimethylsulfoxide (DMSO), $H_3C-C\equiv N$ Acetonitrile

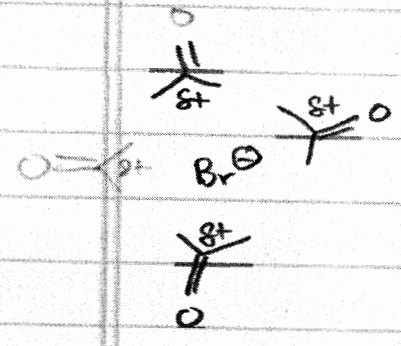
PAS or PAPS

Do not have H bonded to N, O, S

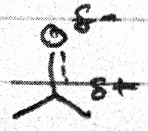
these compounds are polar but not protic!

Resonance reveals this





Resonance Hybrid =



δ+ charge don't stablize

$Br^{\ominus}$ like H-bonds ∴ $Br^{\ominus}$ Nucleophilicity is free to attack!

Ch 9-6

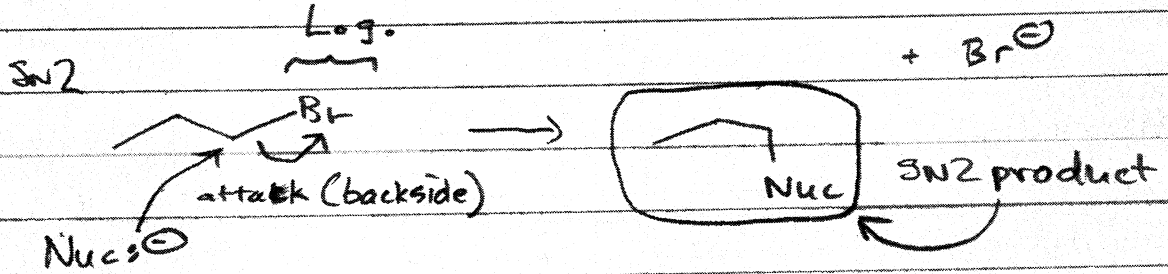
S_N2 rxns like

① good Nuc:$^{\ominus}$ (neg charge) nucleophile

② polar aprotic solvent

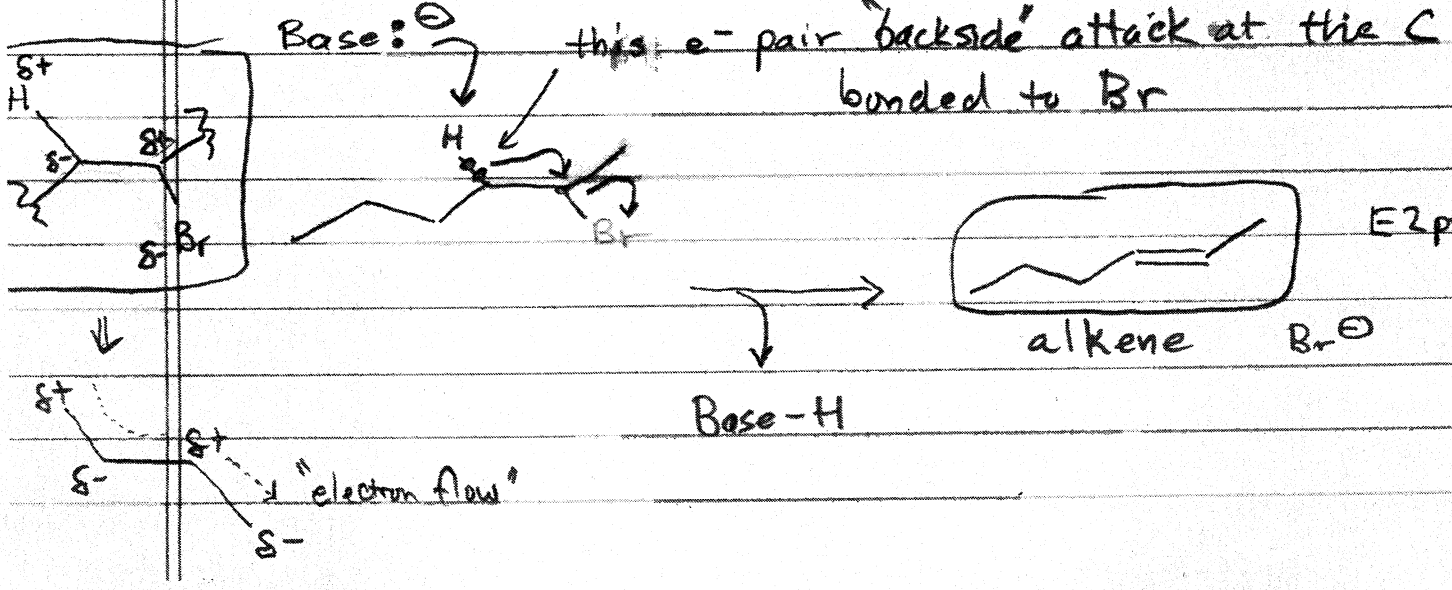
Elimination Rxns E2

In my view S_N2 and E2 rxns are fundamentally identical.



from source external to reactant containing L.g.

E2 : For E2 the Nuc:$^{\ominus}$ is NOW a Base



Ch 9-7

E2 rxn rate = k [alkyl halide]^{1}[Base]^{1} 1+1 = 2 bimolecular

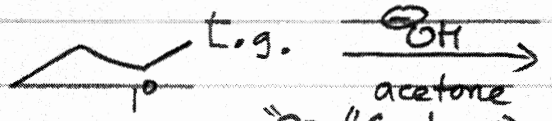
elimination bimolecular

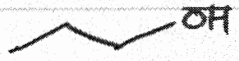
looks similar to SN2 rate

k = [alkyl halide][Nuc] SN2

WHY? 1° (primary) vs 3° (tertiary)

L.g. on 1° C



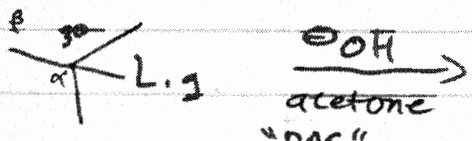


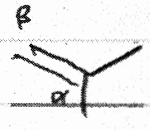
SN2

"PAS" (solvent) see pg Ch7-6

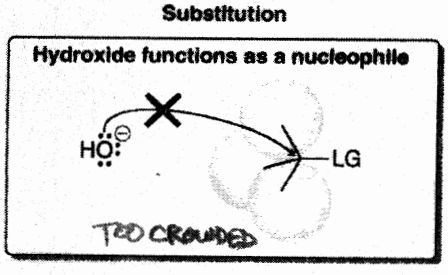
but...

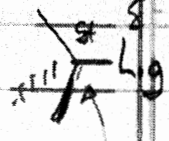
L.g. on 3° C





E2





ideal 5° for SN2, but crowded!

SN2: Difficult for $HO^{\ominus}$ to backside attack sterically hindered C attached to L.g.

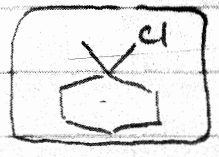
E2: $HO^{\ominus}$ functions as a base and pulls off accessible β-H

Note: C_α is attached to L.g.
C_β is attached to C_α

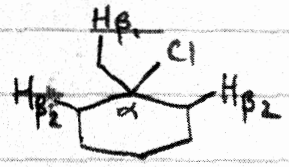
Ch 9-8

Examples

Draw the most abundant E2 product(s)



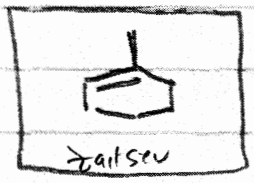
starting material



① Alkyl halide is 3°
② I.D Cα and unique Cβ
③ Base ~~H~~ $(CH_3O^{\ominus})$ ∴ Zaitsev product
E2/SN2

$NaO^{\ominus}CH_3$

① Conditions E2/SN2
② Alkyl halide 3°
③ ∴ E2



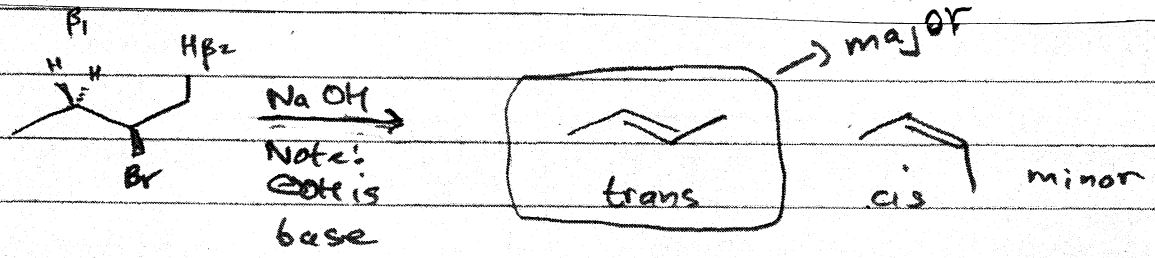
Zaitsev

same

$H\beta_2$ /Cl elimination

$C_\alpha = C_{\beta_2}$

so dont include this as 2nd product

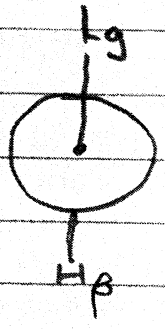


Major E2 product

Zaitzev

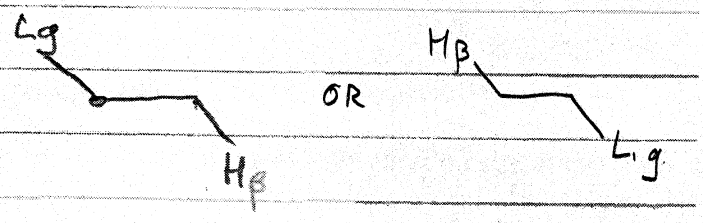
Stereospecificity

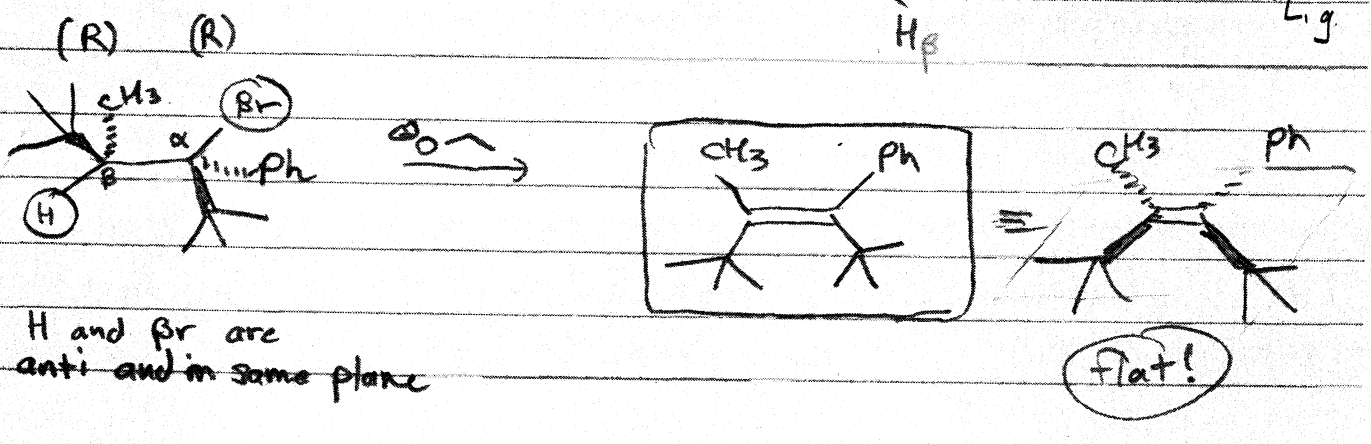
How must Hβ and L.g. be oriented for E2 rxn?



anti and line up (antiperiplanar)

from side

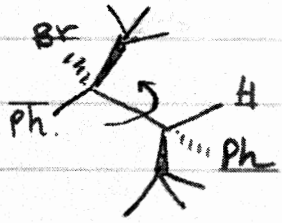


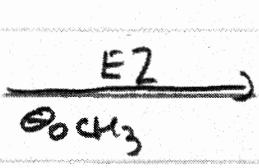


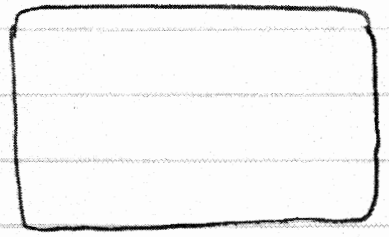
H and Br are anti and in same plane

Ch9-10

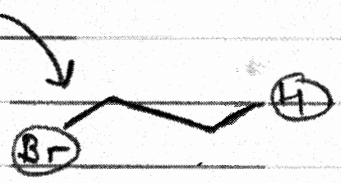
What if drawn as follows, show E2 product





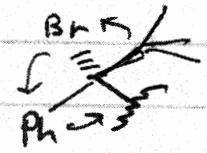


① Need to rotate molecule until H and Br are anti and in same plane Goal



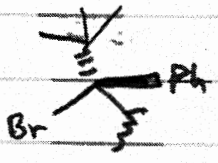
② Add other groups to each C using wedges ◣ and ||||| bonds

original

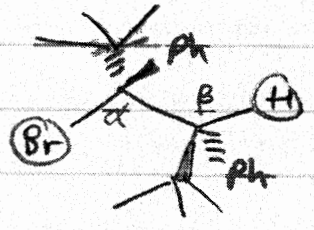


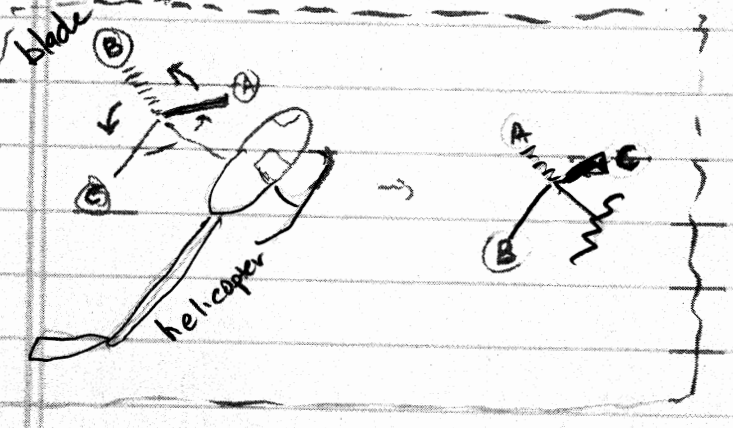
rot 60° CCW

rotated

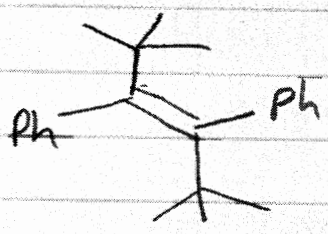


now join to other half





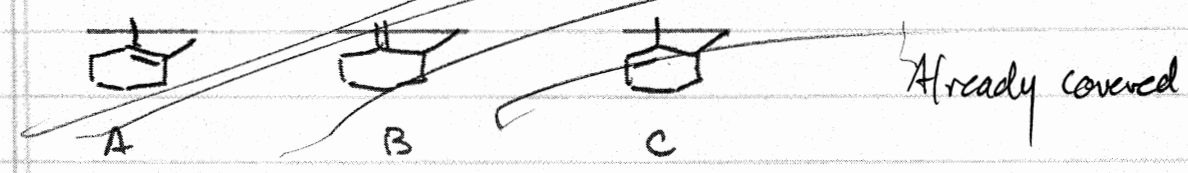
↓ E2 $C_\alpha = C_\beta$



STOP HERE

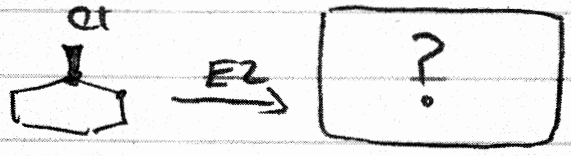
Ch 9-11

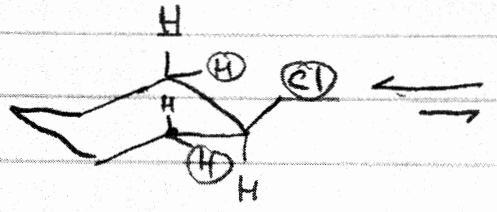
Arrange in order of stability

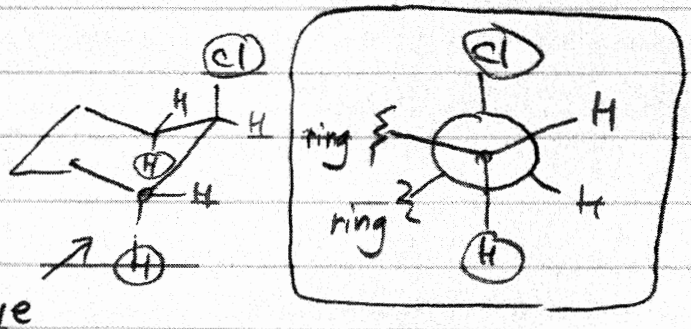


Already covered

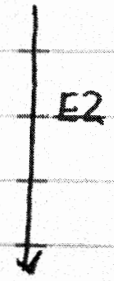
Stereospecificity of E2 rxn w/ substituted Cyclohexanes



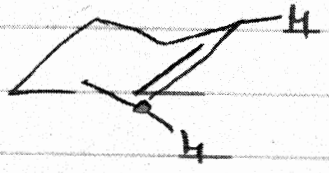




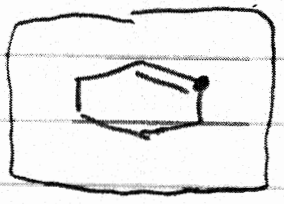
Eye



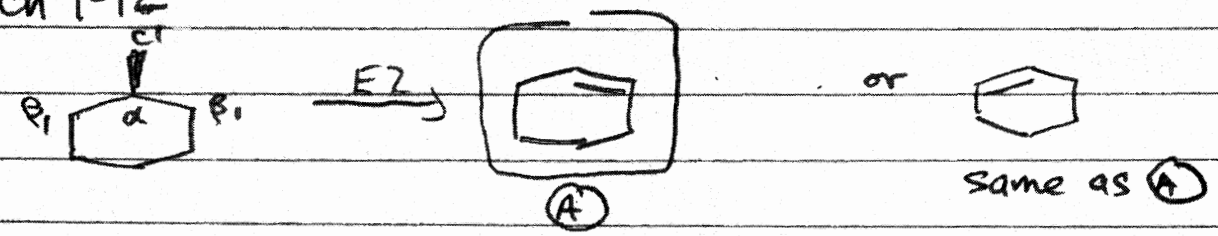
Anti-periplanar arrangement, set for E2! when Cl and H are axial



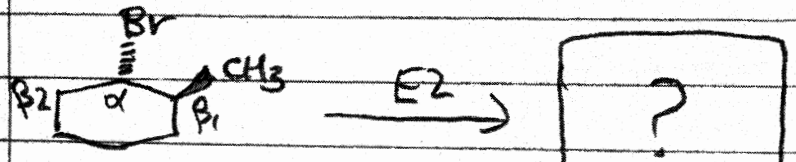
III



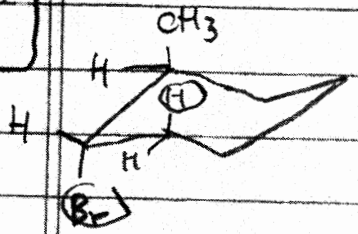
Ch 9-12



(A)



Approach 1



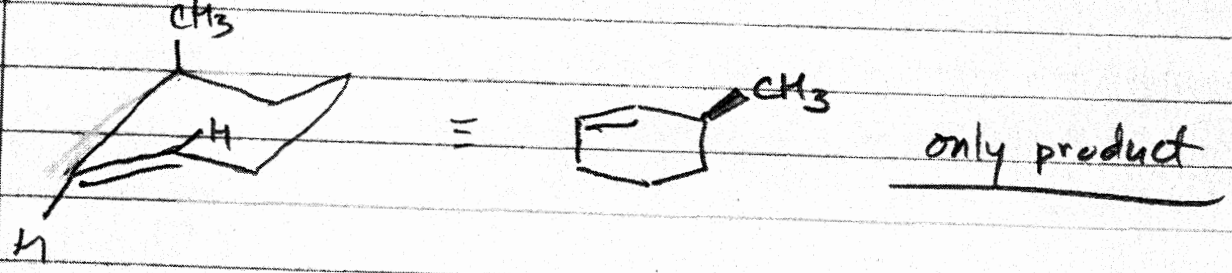
① Choose position on chair where Br (L.g.) is axial down ("down" because that is how it's draw in perspective drawing.

② Determine if β carbons are different (i.e. unique)

③ Determine if β-C have β-H

④ If β-H can it be axial and anti to the Br (or L.g.)?

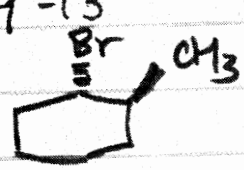
⑤ If anti AND axial E2 can occur there



only product

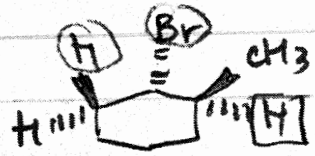
Approach 2

Ch 9 - 13



E2 → ?

① Draw β-H on wedged (▬) or dashed (≡) bond



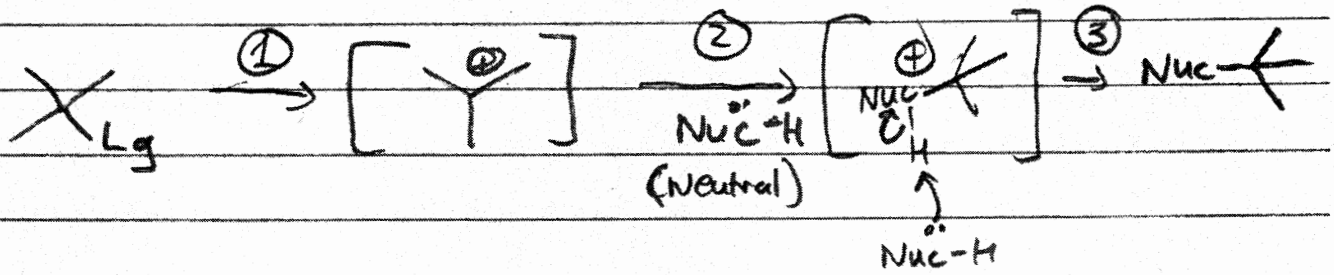
② Note: (Br) and circled (H) are on opposite sides of the ring -- they are "anti"/trans

the (Br) and boxed [H] are on same side of ring -- they are "syn"/cis and ∴ cannot be E2 eliminated

ONLY (Br) and (H) can be eliminated via E2

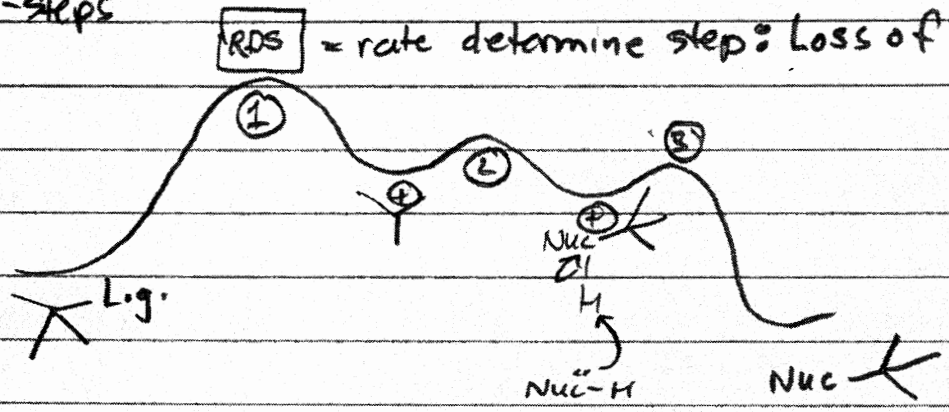
Ch 9 - 14

Sn1 (unimolecular) nucleophilic substitution



3-steps

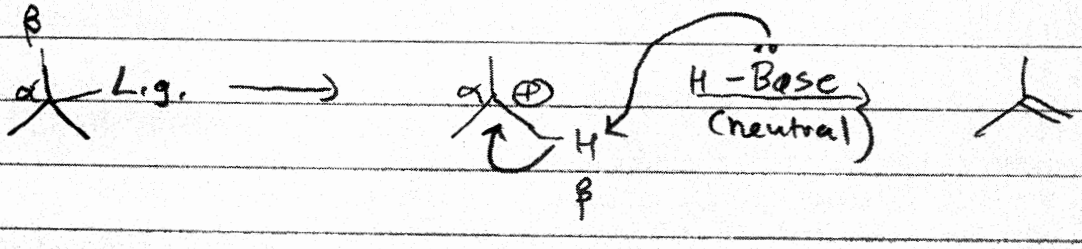
RDS = rate determine step: Loss of L.g.

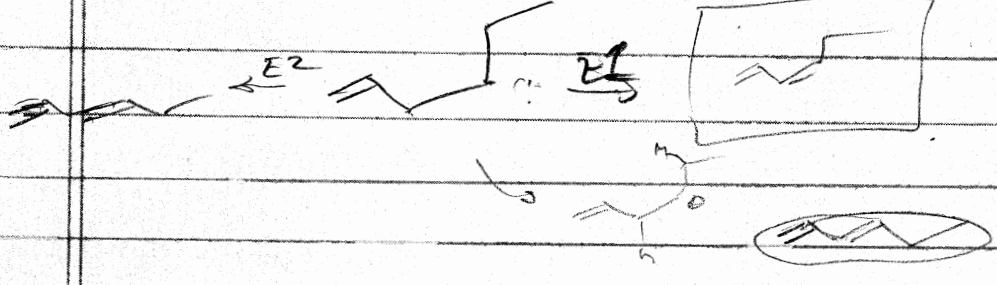


E① is very similar to Sn1 mechanism

(unimolecular)

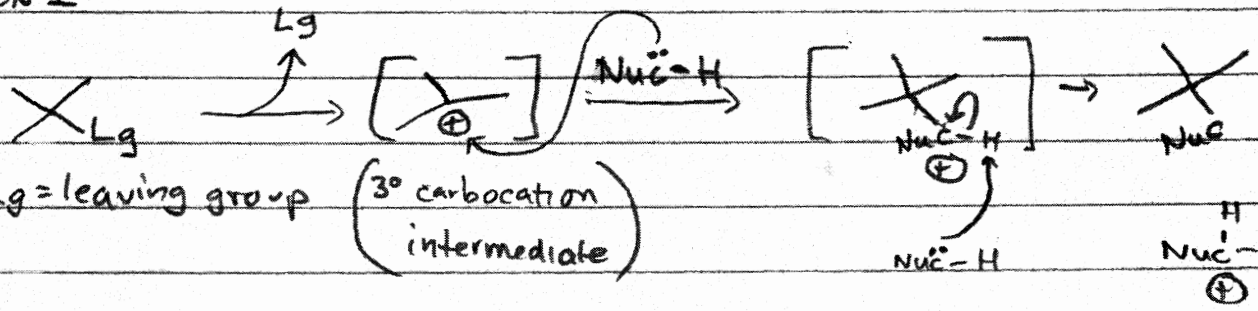
→ Elimination

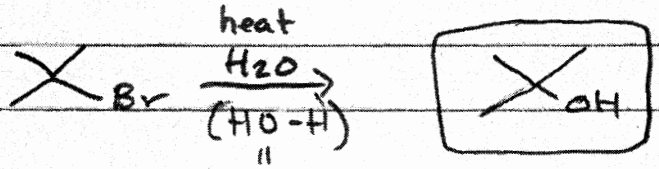




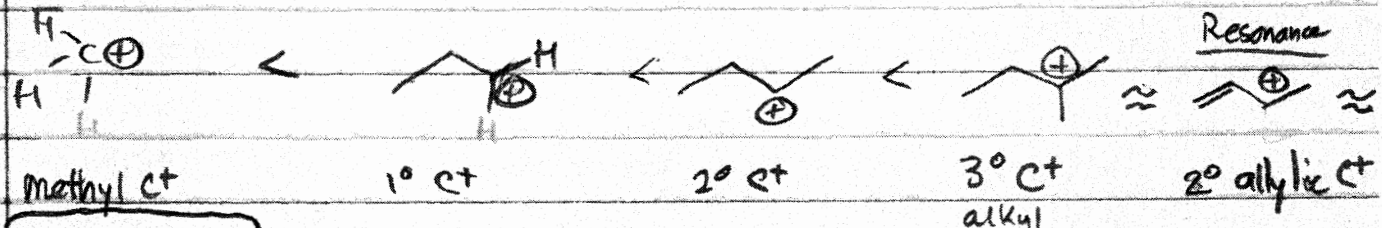
Ch 9 - 15

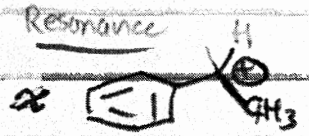
SN1





Carbocation Stability

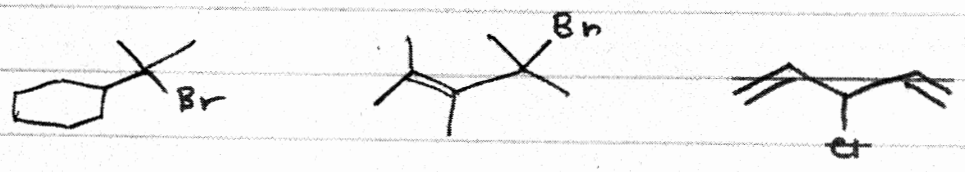




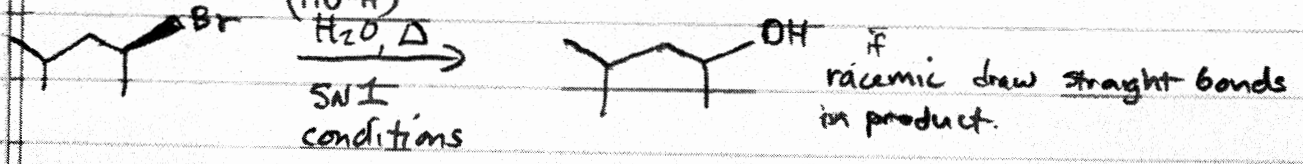
Since SN1 reactions form C+, SN1 rxn rates favor the formation of stable C⊕, such as 3°C⊕, allylic C⊕, benzylic C⊕

Ch 9 - 16

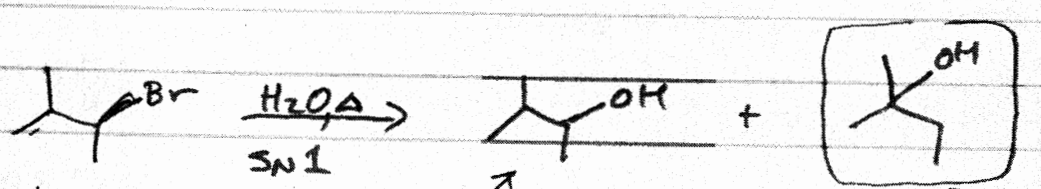
Draw the carbocation made after the L.g. leaves.
If resonance structure stablizes ⊕ charge, draw 1 resonance structure



S_N1 (Nuc-H) (HO-H)



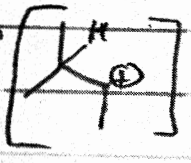
if racemic draw straight bonds in product.



How?

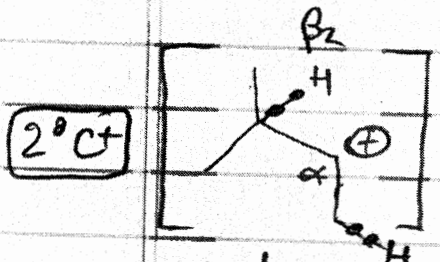
① Draw ⊕ S_N1

Direct HOH attack



② Identify ⊕ substitution

1°, 2°, 3° ?



2° C⊕

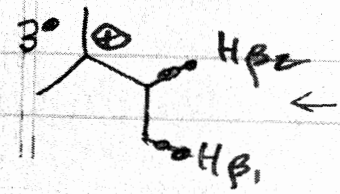
Ⓐ The ⊕ is α C I.D. unique C_β.

Ⓑ Does C_β have a CH_3 or H attached?

Ⓒ Move $:CH_3$ or :H w/ both e⁻ to form new bond where ⊕ is

Ⓓ Is New ⊕ more stable than original ⊕? If yes, migration is possible.

H_{β_2} migrath



3° C⊕ more stable

← results from H_{β_2} migration