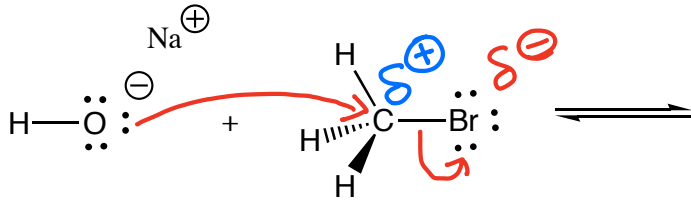
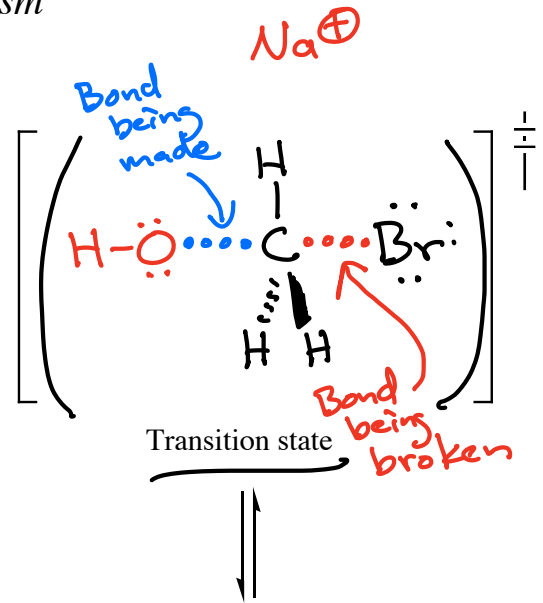


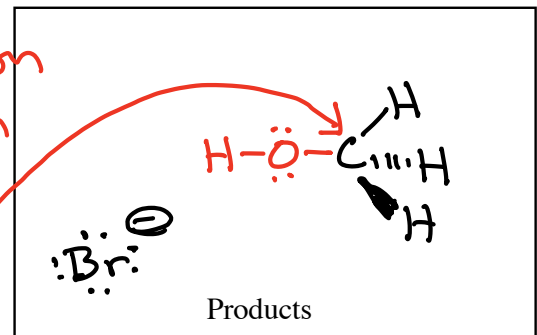
# The $S_N2$ Mechanism



**Nucleophile**  $\rightarrow$  must attack at the back of the C-Br bond.  $\Rightarrow$  This angle and direction of attack helps break the C-Br bond



The configuration at this carbon atom is inverted

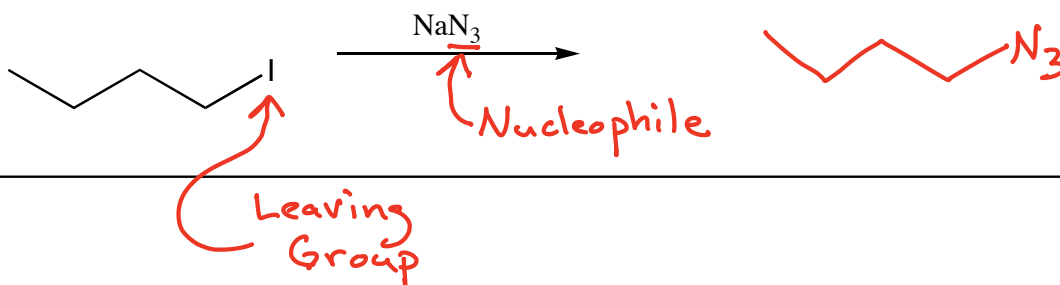


Summary: The nucleophile attacks by making a new bond to C from the back of the C-X bond just as X leaves

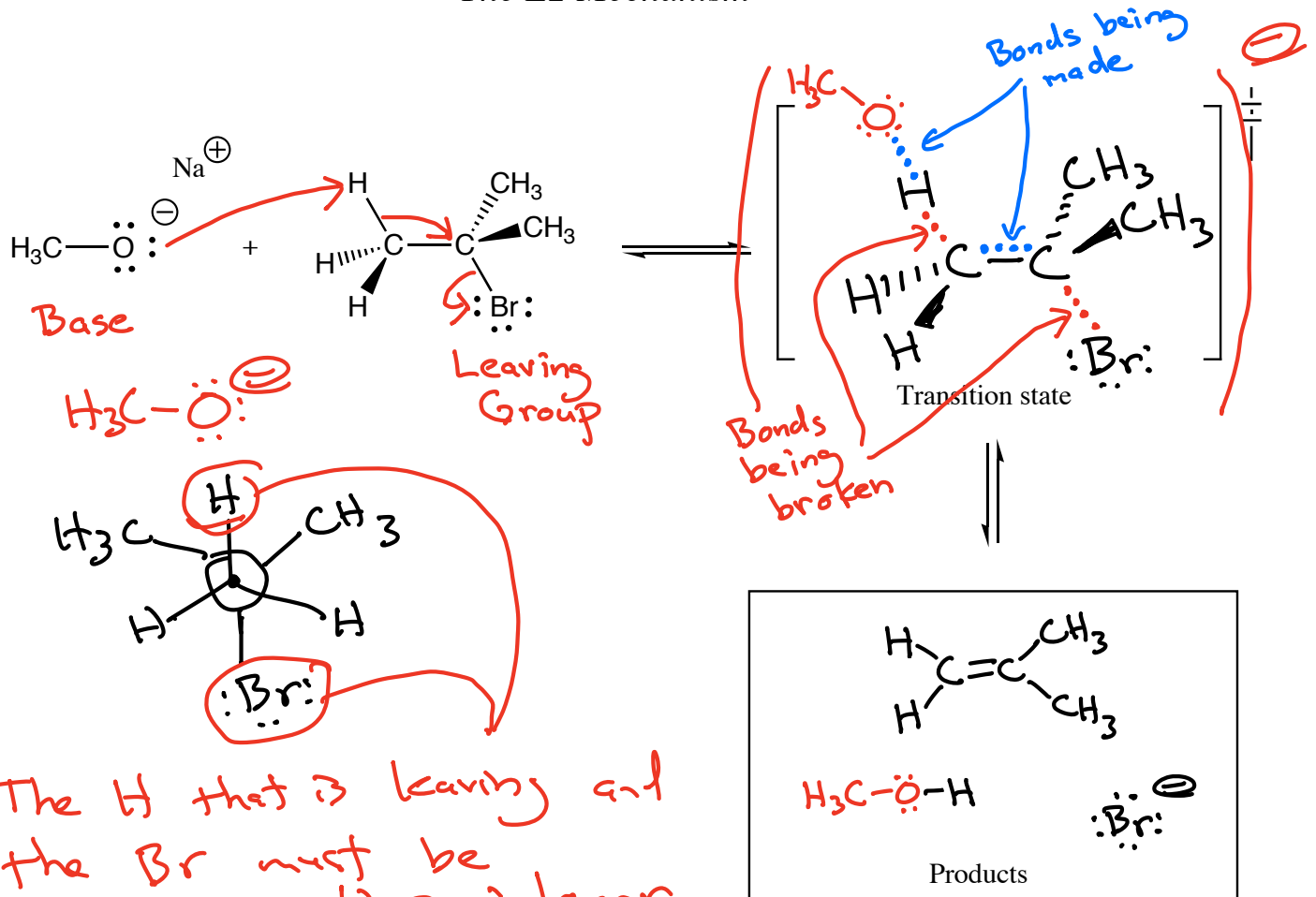
Regiochemistry: *N/A*

Stereochemistry: **INVERSION** at the site of reaction

Example:



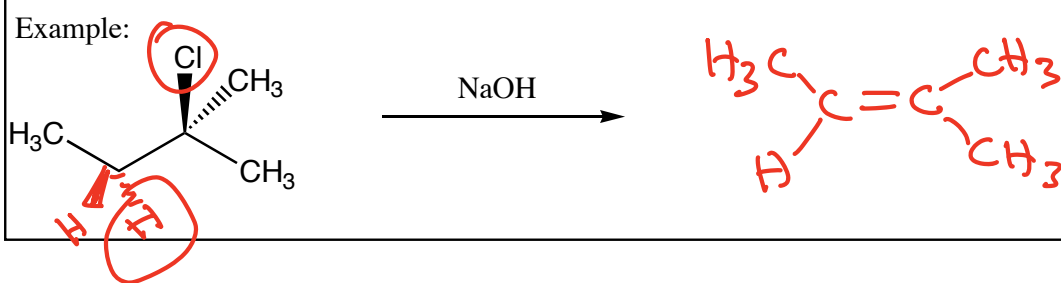
## The E2 Mechanism



Summary: Base removes an H atom as a pi bond forms and the Br atom leaves  
 → The H and Br must be anti-periplanar

Regiochemistry: Zaitsev's Rule → most stable alkene product

Stereochemistry: Determined by anti-periplanar transition state



Zaitsev's Rule  $\Rightarrow$  When there is a choice,

More alkyl groups (fewer H atoms on the  $sp^2$  C atom of alkene)  $\left\{ \begin{array}{l} \text{the more stable alkene} \\ \text{will be the predominant} \\ \text{product.} \end{array} \right.$

(trans over cis)

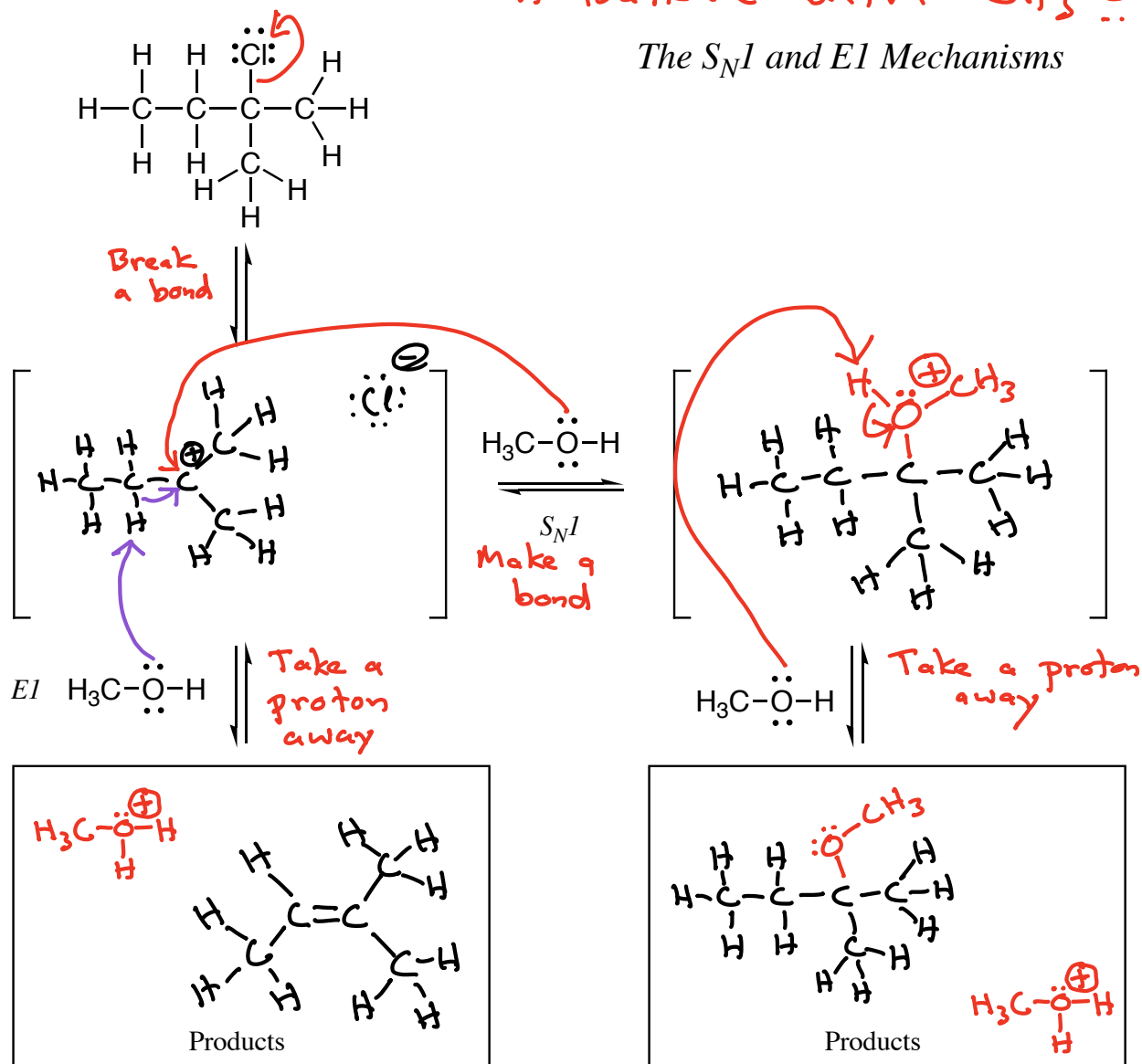
3<sup>rd</sup> and 4<sup>th</sup> Mechanisms  $\rightarrow$  these always occur together

$S_N1$  and  $E1$

Unimolecular  $\rightarrow$  only the haloalkane is involved in the rate-limiting (slow) step of the reaction

# Haloalkane with $\text{CH}_3\ddot{\text{O}}\text{H}$

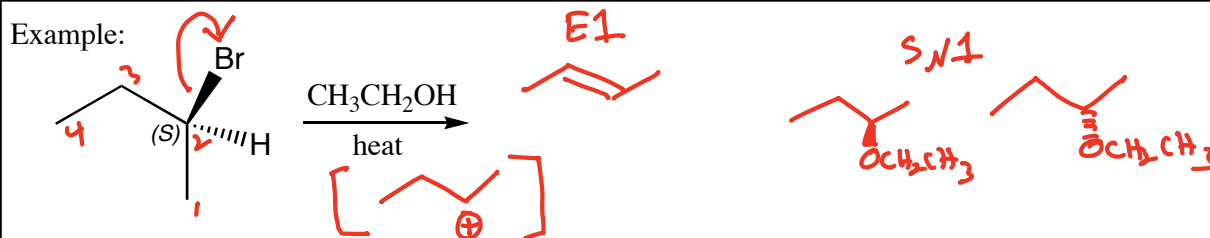
## The $\text{S}_{\text{N}}1$ and $\text{E}1$ Mechanisms



Summary: For sterically hindered haloalkanes, the C-X bond breaks to give a carbocation intermediate that either reacts as an electrophile ( $\text{S}_{\text{N}}1$ ) or has a proton taken away ( $\text{E}1$ )

Regiochemistry:  $\text{E}1 \rightarrow$  Zaitsev's Rule

Stereochemistry:  $\text{S}_{\text{N}}1 \rightarrow$  Scrambled  $\rightarrow$  not quite 1:1 exactly



These four mechanisms  $S_N2$ ,  $E2$ ,  $S_N1$ ,  $E1$  compete with each other

To understand which mechanism is appropriate, we analyze:

- 1) The nucleophile/base
- 2) The nature of the haloalkane

Nucleophiles are also bases



Electron rich molecule that can make a new bond



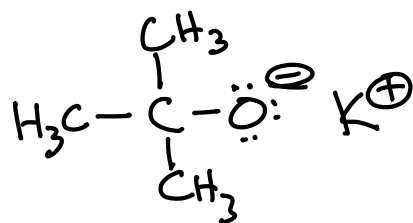
Electron rich molecule that can bond to a proton

## Table of Nucleophiles

<p><b>Strong Nucleophiles</b></p> <p><math>\text{Br}^-</math>, <math>\text{I}^-</math>, <math>\text{R-S}^-</math>, <math>\text{H-S}^-</math>, <math>\text{N}\equiv\text{C}^-</math>, <math>\text{N}_3^-</math></p> <p><math>\text{R-C}\equiv\text{C}^-</math>, <math>\text{R-O}^-</math>, <math>\text{H-O}^-</math>      Strong Bases</p>
<p><b>Medium Nucleophiles</b></p> <p><math>\text{R-CO}_2^-</math>, <math>\text{R-S-H}</math>, <math>\text{R}_2\text{S}</math>, <math>\text{NH}_3</math>, <math>\text{RNH}_2</math>, <math>\text{R}_2\text{NH}</math>, <math>\text{NR}_3</math></p>
<p><b>Weak Nucleophiles</b></p> <p><math>\text{R-CO}_2\text{H}</math>, <math>\text{R-O-H}</math>, <math>\text{H}_2\text{O}</math>      Very Weak Bases</p>

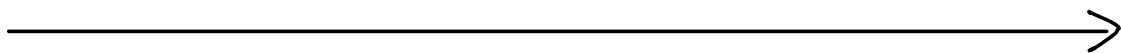
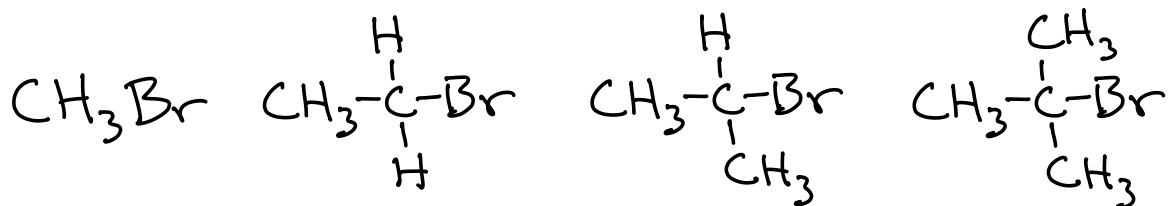
### Special Case

Tert-Butoxide ( $\text{tBuO}^-$ ) is a strong base, but is not a nucleophile due to steric hindrance.



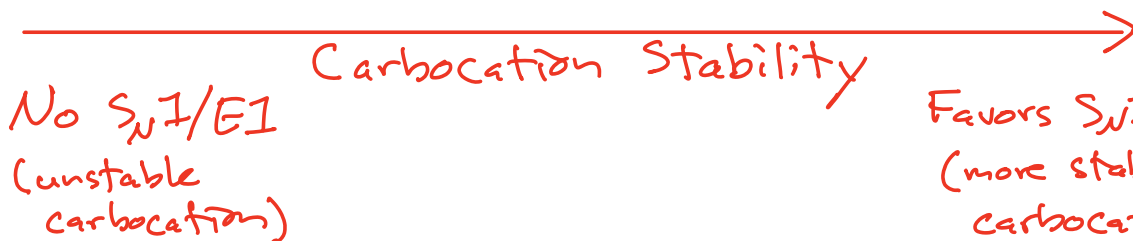
" $\text{KOtBu}$ "  
or  
" $\text{tBuO}^-$ "

## Haloalkanes



$\text{S}_{\text{N}}2$   
preferred

$\text{S}_{\text{N}}2$   
prevented  
(steric strain)



No  $\text{S}_{\text{N}}1/\text{E}1$   
(unstable carbocation)

Carbocation Stability

Favors  $\text{S}_{\text{N}}1/\text{E}1$   
(more stable carbocation)

Strong base prefers  $\text{E}2$

## Substitution/Elimination Decision Map

Methyl Halide  $\Rightarrow$   $S_N2$

Primary Haloalkane  $\Rightarrow$   $tBuOK?$   $\Rightarrow$  Yes  $\Rightarrow$  E2

No  $\Rightarrow$   $S_N2$

Secondary Haloalkane or Allylic/Benzylic Halides  $\Rightarrow$  Very Weak Base?  $\Rightarrow$  Yes  $\Rightarrow$   $S_N1/E1$  \*

Very Strong Base?  $\Rightarrow$  Yes  $\Rightarrow$  E2 \*\*

No  $\Rightarrow$   $S_N2$

Tertiary Haloalkane  $\Rightarrow$  Very Weak Base?  $\Rightarrow$  Yes  $\Rightarrow$   $S_N1/E1$

No  $\Rightarrow$  E2

For  $S_N2$  Remember Chiral Center INVERSION  
 For E2 Remember anti-periplanar and Zaitsev  
 For  $S_N1$  Remember Chiral Center Scrambling  
 For E1 Remember Zaitsev

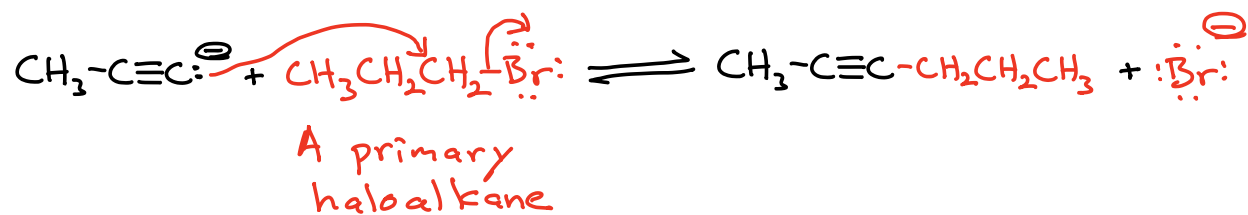
\* Note: With Very Weak Bases,  $S_N2$  can compete here, but for the purposes of this class, assume  $S_N1$  / E1 predominate

\*\* Note: If  $tBuOK$  is the very strong base, an appreciable amount of a non-Zaitsev product can be formed because the bulky  $tBuOK$  will tend to react with the most accessible H atom.





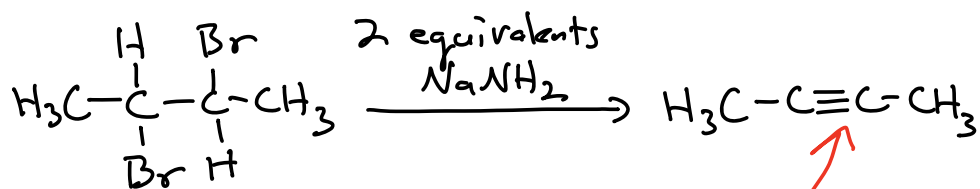
## Epic New Reaction



Time capsule: This is an  $\text{S}_{\text{N}}2$  reaction. The haloalkane must be primary to avoid an  $\text{E}2$  reaction.



c) Conversion of a vicinal dihalide into an alkyne



Vicinal dihalide

Note this alkyne is not terminal  
(it is not on the end)



Time capsule → This is a double E2 reaction



