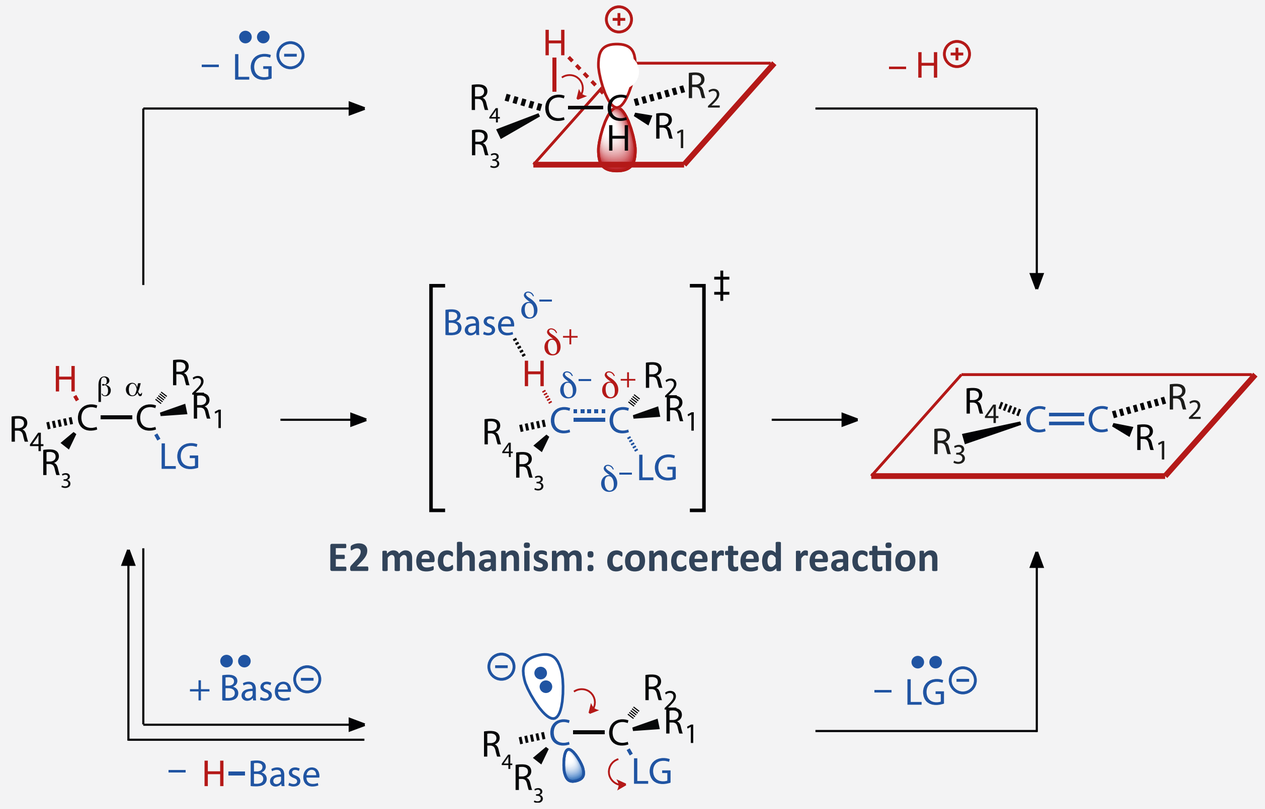
4.4 Elimination Reactions (E1, E2, $E1_{CB}$)

β-Hydrogen Eliminations

E1 mechanism: leaving group leaves first, hydrogen leaves subsequently



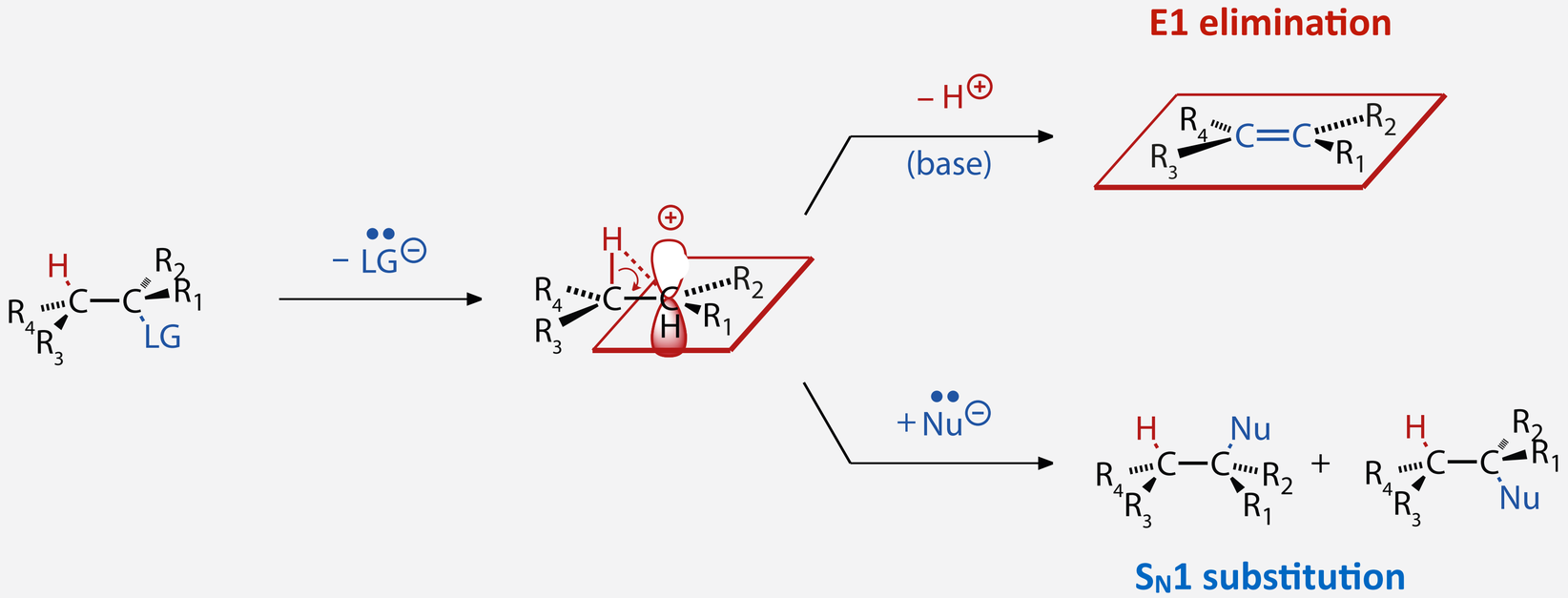
E2 mechanism: concerted reaction

E1$_{cb}$ mechanism: base first removes hydrogen, then leaving group leaves

- most common are eliminations of hydrogen (H) and leaving group (LG) on adjacent carbons

E1 Reactions and Competition with S_N1 Substitutions

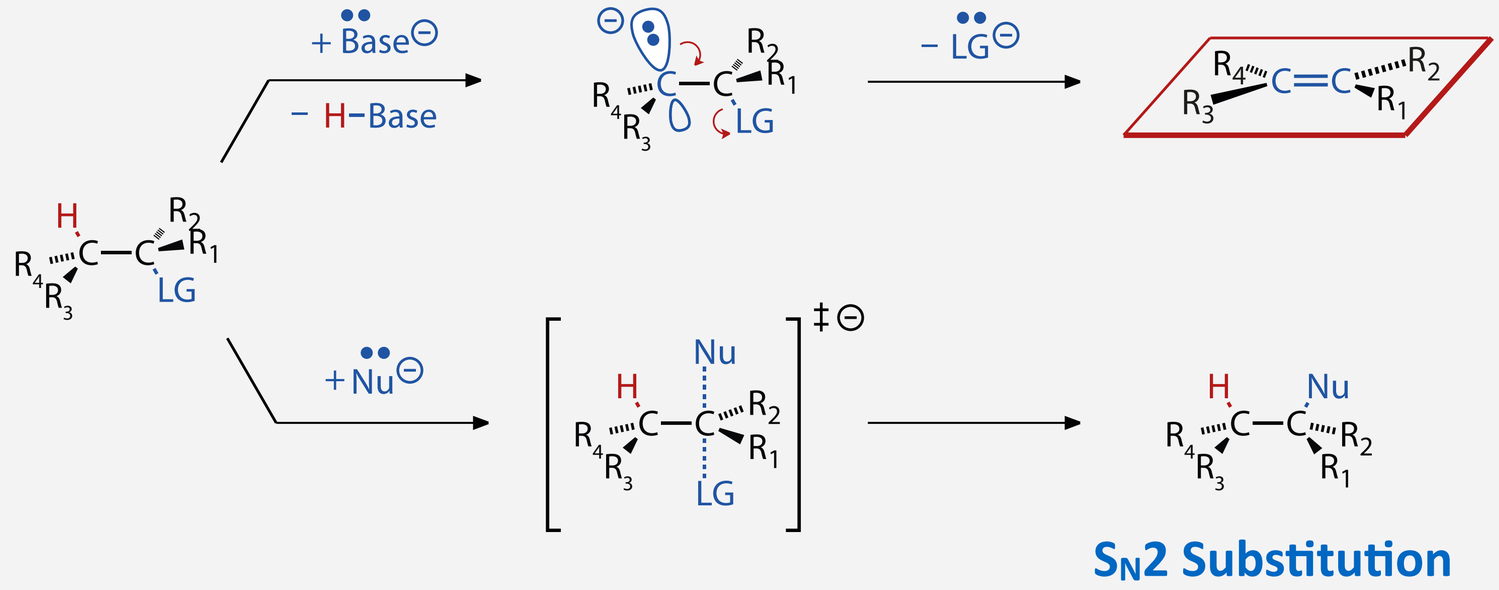
- E1 reactions require good leaving group and adjacent proton, absence of a base/nucleophile



- **first step of E1 reaction is carbocation generation, conditions & intermediate as S_N1 reaction**
- **therefore E1 eliminations are inevitable side reactions of S_N1 reactions !**
- **E1: absence of a nucleophile, no or weak base, acidic β-hydrogens, high temperature !**
- **S_N1: presence of a good (not too basic) nucleophile, few or non-acidic β-hydrogens**

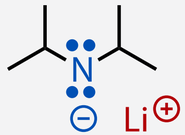
$E1_{cb}$ Reactions and Competition with S_N2 Substitutions

- $E1_{cb}$ reactions require strong base, deprotonation of starting material to the “conjugate base”

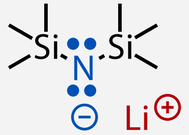


- **$E1_{cb}$ and S_N2 reactions do not share the same reaction intermediate/pathway**
- **conditions similar because all good nucleophiles are bases, most bases are nucleophiles**
- **$E1_{cb}$ or E2 eliminations are often observed as side reactions of S_N2 reactions**
- **$E1_{cb}$ or E2: moderate/poor leaving group, strong “non-nucleophilic base”, high temperature!**
- **S_N2: good, weakly basic nucleophile (e.g., I^-, RS^-, PR_3, H_2O), few or non-acidic β-hydrogens**

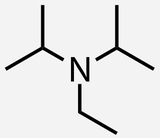
Non-Nucleophilic Bases



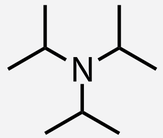
lithium diisopropylamide
LDA, $pK_A \approx 40$



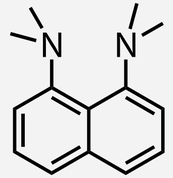
lithium hexamethyldisilazide
LHMDS, $pK_A \approx 40$



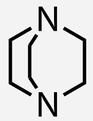
diisopropylethylamine
DIEA, $pK_A \approx 10$



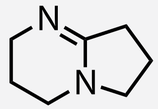
triisopropylamine
TIPA, $pK_A \approx 10$



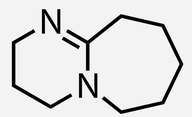
1,8-bis(dimethylamino)naphthalene
proton sponge, $pK_A \approx 12$



1,4-diazabicyclo[2.2.2]octane
DABCO, $pK_A \approx 12$



1,5-diazabicyclo[4.3.0]non-5-ene
DBN, $pK_A \approx 12$



1,8-Diazabicyclo[5.4.0]undec-7-ene
DBU, $pK_A \approx 12$

- non-nucleophilic bases are good bases (high pK_A of BH) but are strongly sterically hindered!

Learning Outcomes

- molecules with leaving groups and acidic protons undergo eliminations
- eliminations compete with substitution reactions, similar conditions
- eliminations generally favored at high temperatures (reaction entropy!)