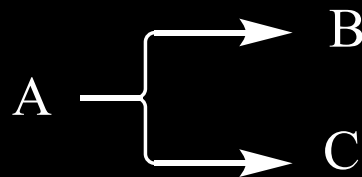
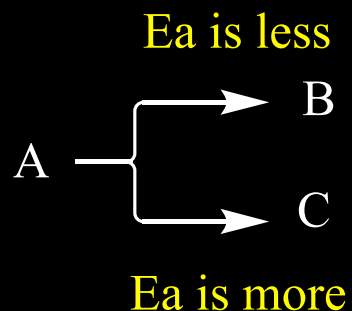


Thermodynamic and kinetic control of a reaction



If multiple products possible for a reaction, then ratio of the products can be dictated by

☆ Relative energies of transition states - **Kinetic Control**

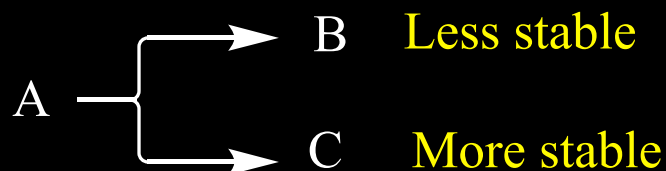


A to B rate is faster

B will be the major product

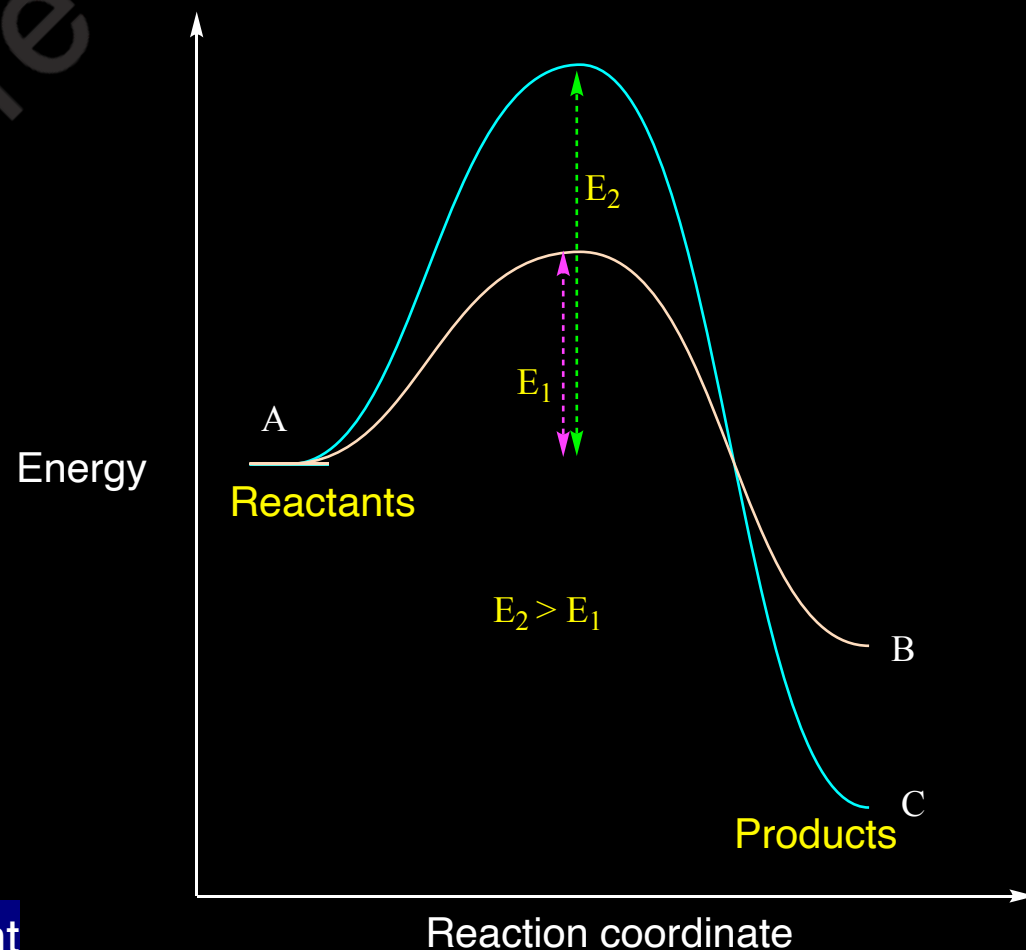
☆☆☆ Speed is important

☆ Relative energies of the products- **Thermodynamic Control**

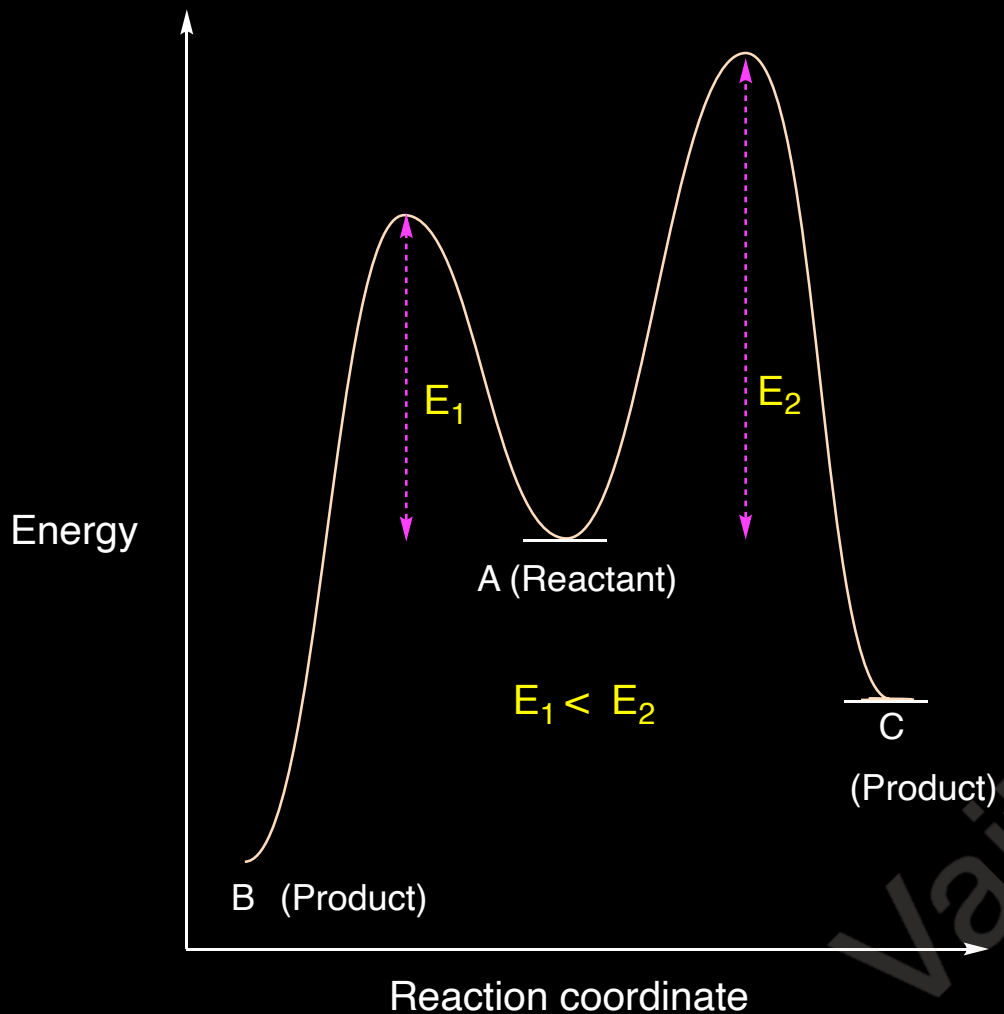


C will be the major product

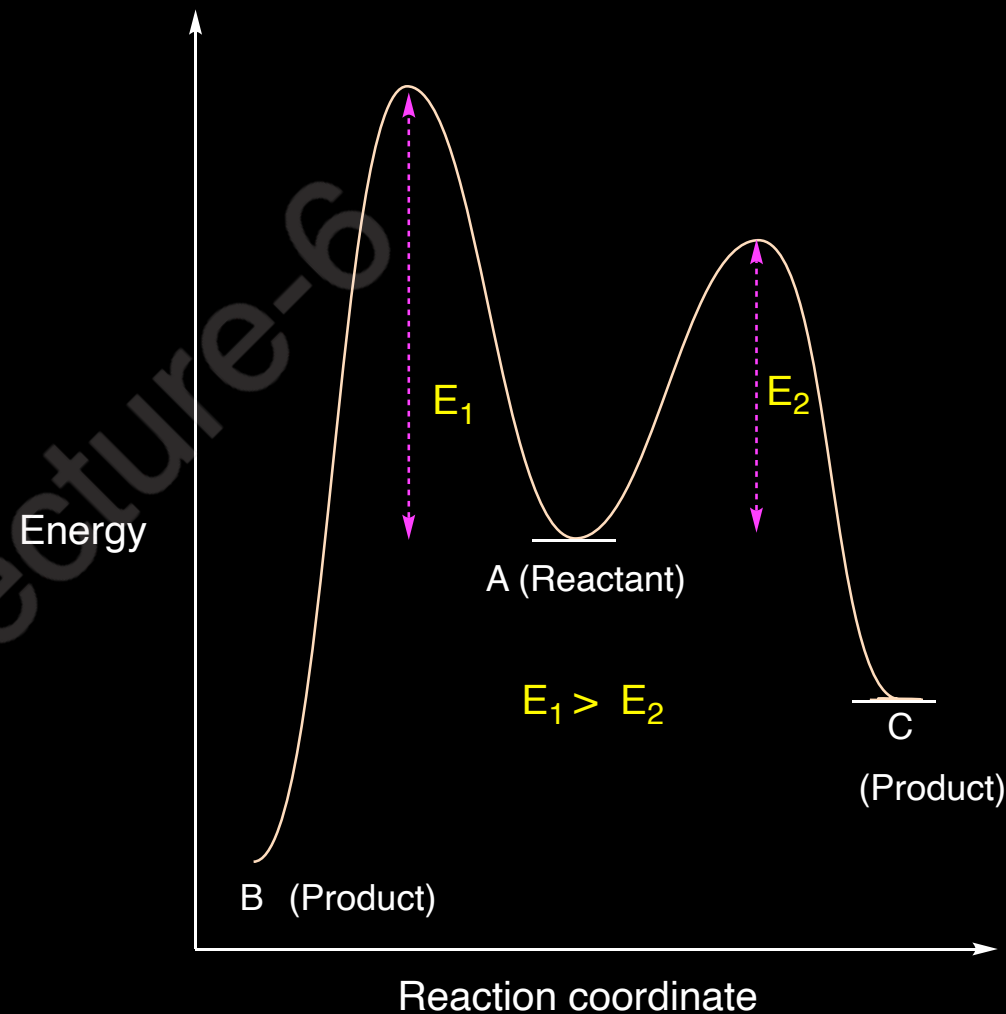
☆☆☆ Stability is important



Thermodynamic and kinetic requirements of a reaction

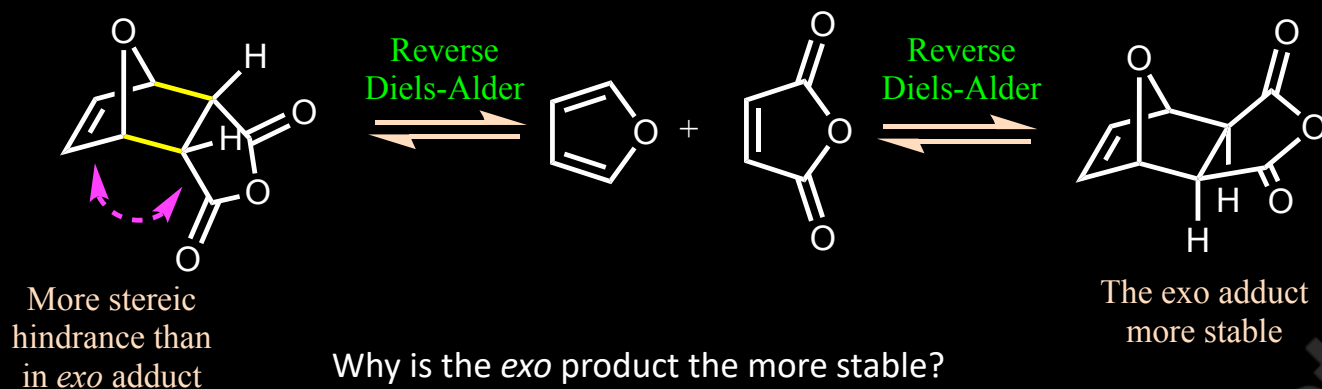


- ☆ Under Kinetic control: Major Product is **B**
- ☆ Under Thermodynamic control: Major Product is **B**

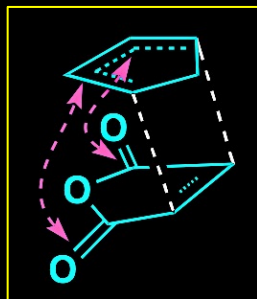


- ☆ Under Kinetic control: Major Product is **C**
- ☆ Under Thermodynamic control: Major Product is **B**

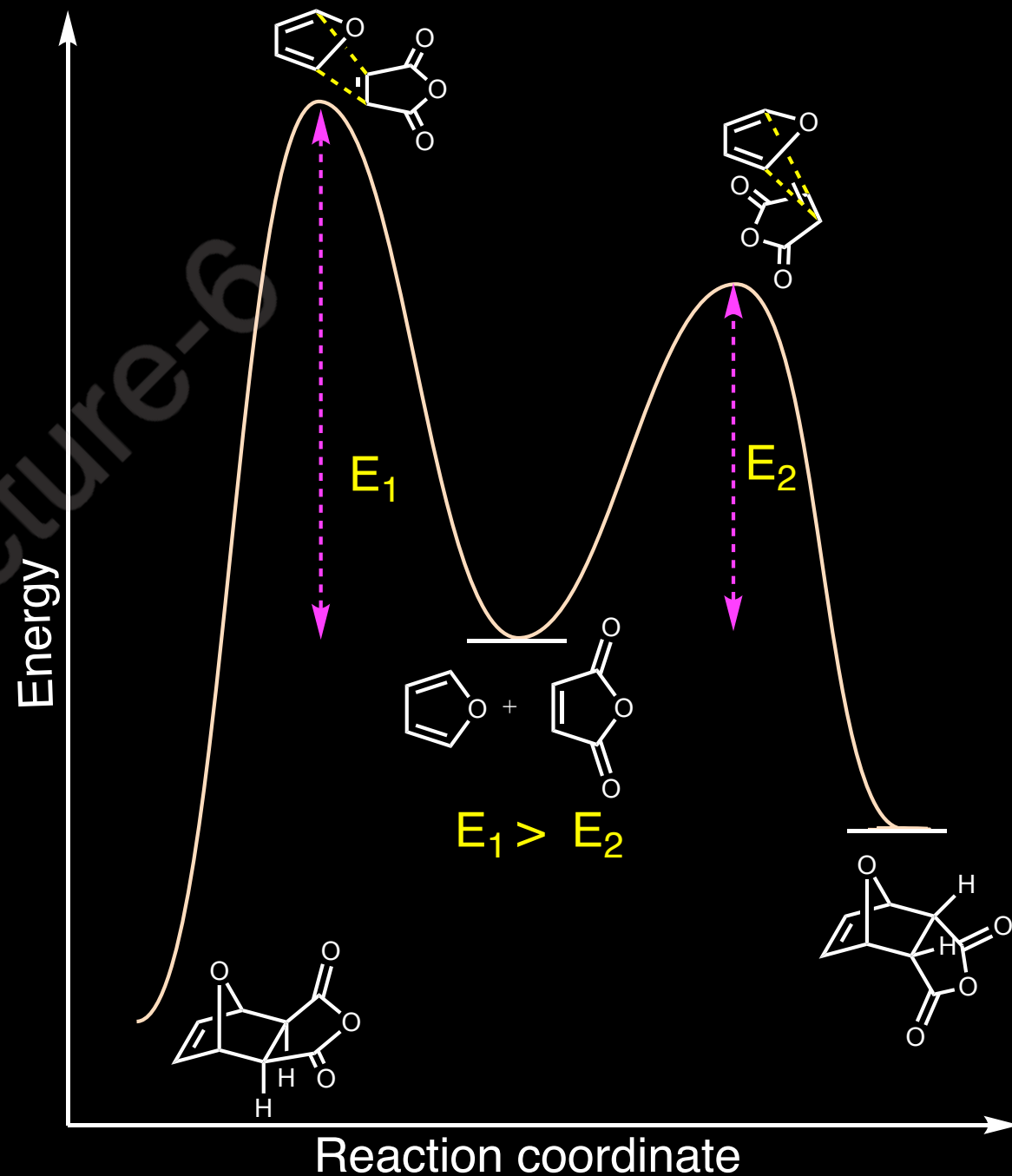
**Thermodynamic and kinetic requirements
For Diels-Alder reaction**



Why is the *endo* product the more predominant than *exo* product?



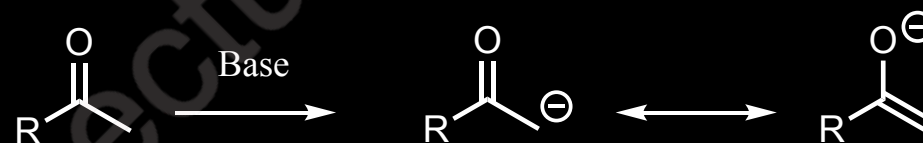
bonding interaction in transition state
between C=O groups and back of diene



Carbanion: By the removal of a proton from a carbon by a Bronsted base.



Enolate anion: By the removal of a proton from a carbon alpha to a carbonyl group.



Condition: Acidity of C-H bond greater than the acidity of conjugate acid of the base used for deprotonation



Formation of enolate depends

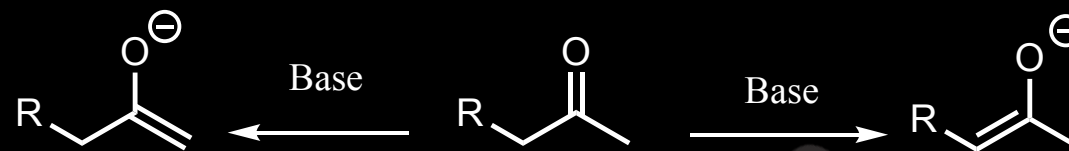
Acidity of C-H bond and Base

The acidity of C-H bond depends on the functional group attached to it. The order of acidity,



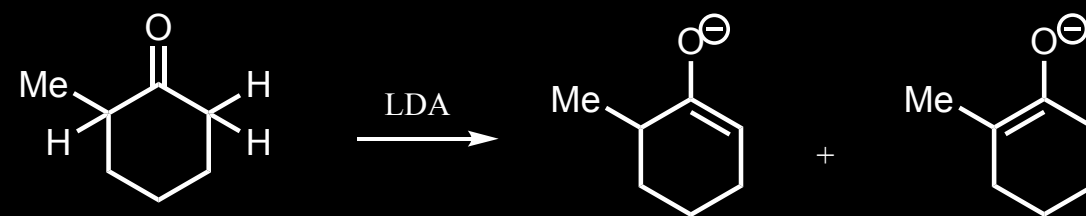
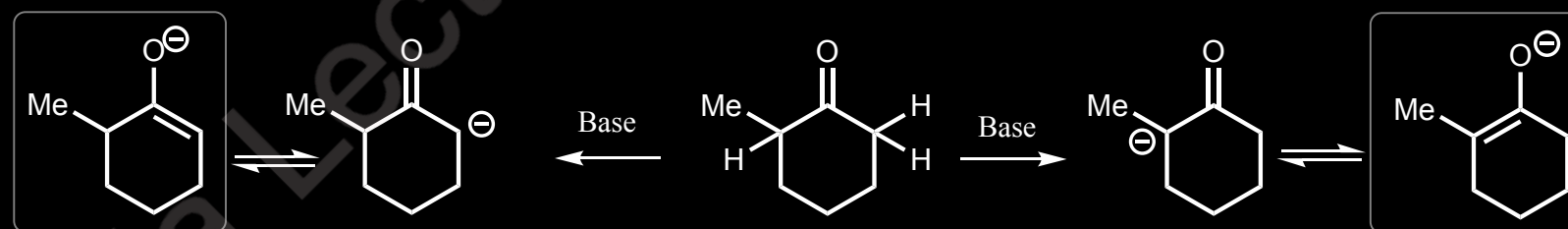
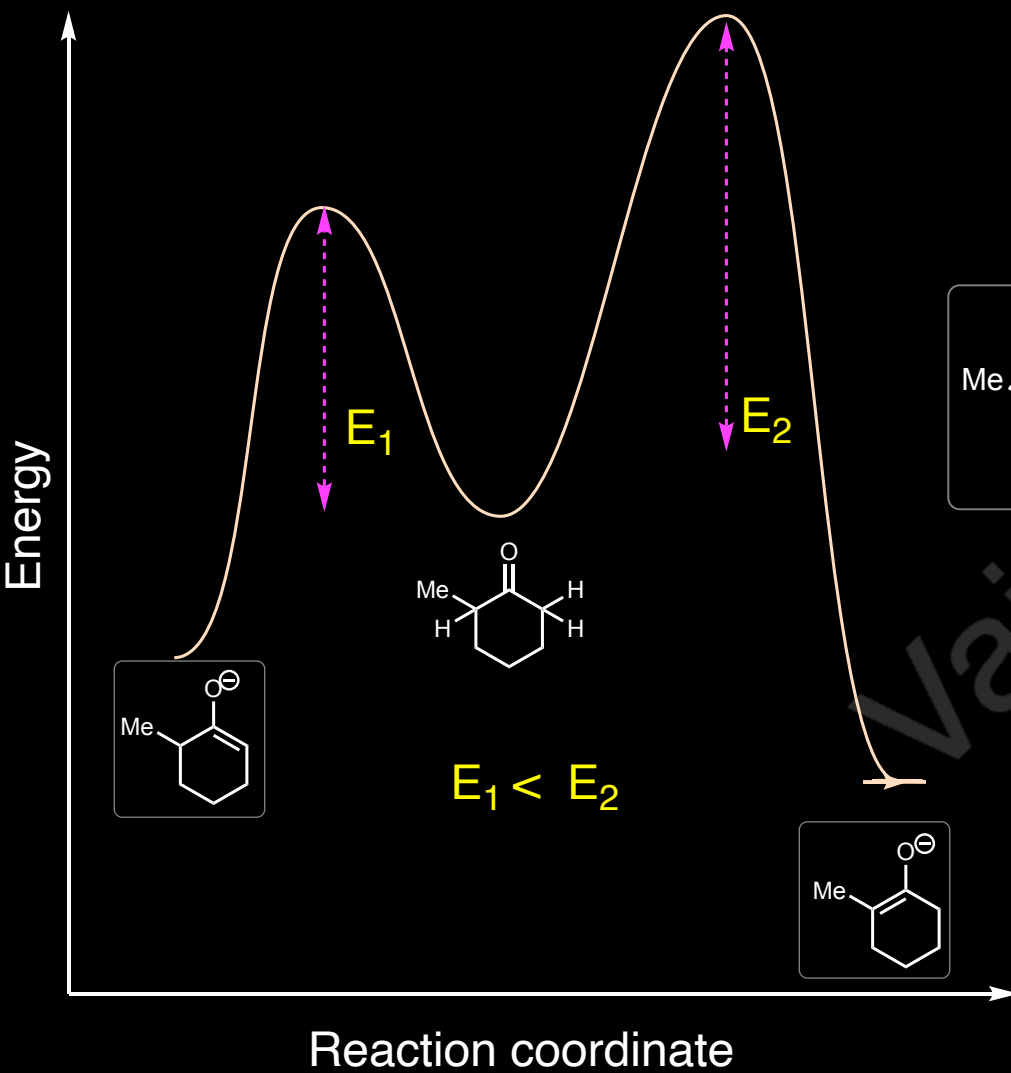
Thermodynamic and kinetic control of a reaction

Regioselectivity

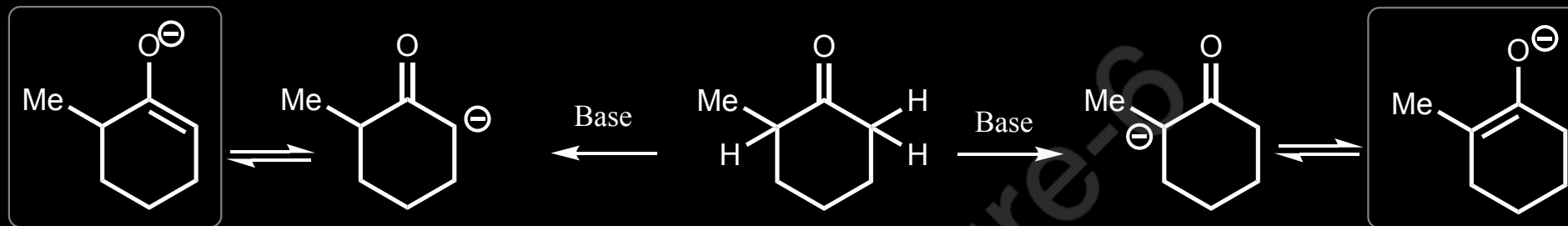


How to control ?

Experimental conditions:
Kinetic control
Thermodynamic control



at -78 °C	99	:	1
heat	10	:	90

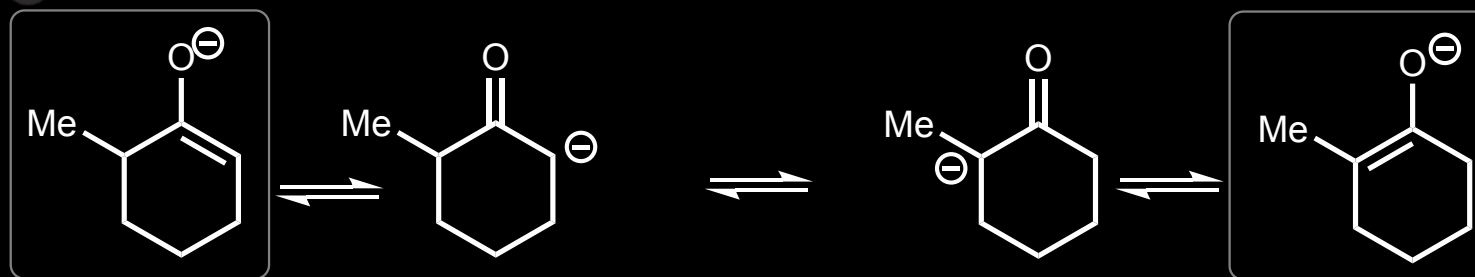


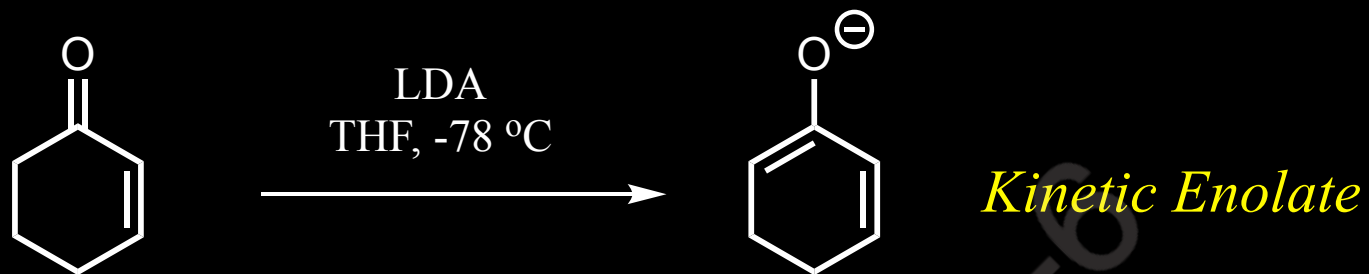
Kinetic control

- ☆ Low temperature
- ☆ Use bulky base
- ☆ Strong base
- ☆ Short reaction times

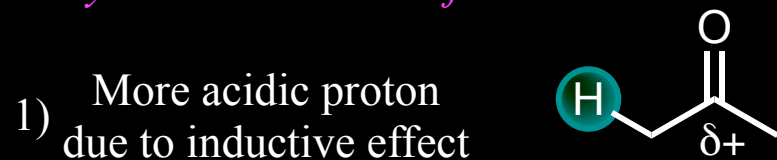
Thermodynamic control

- ☆ High Temperature
- ☆ Weak base
- ☆ Long reaction times

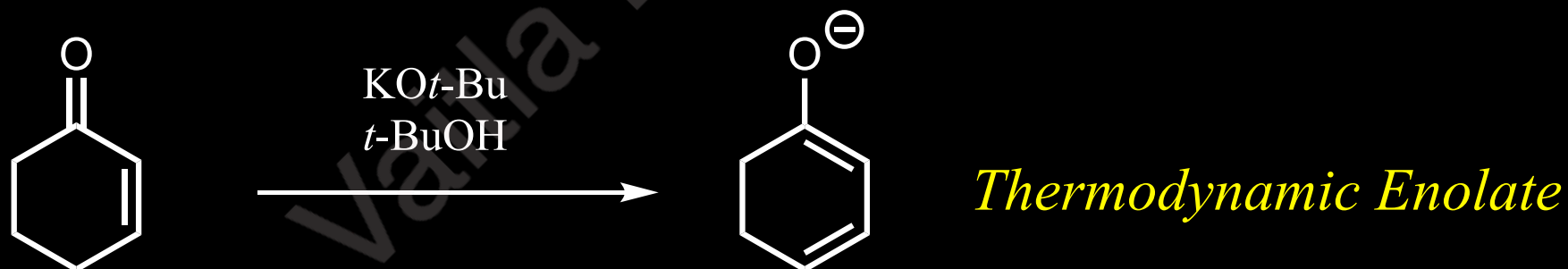
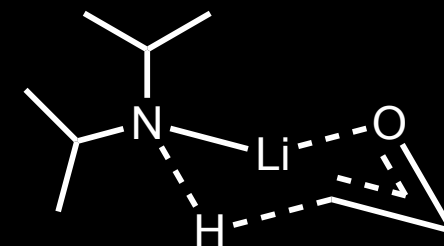




Why Kinetic enolate is favorable under these conditions?



2) coordination of the lithium by the carbonyl oxygen orients the base into a 6-membered transition state

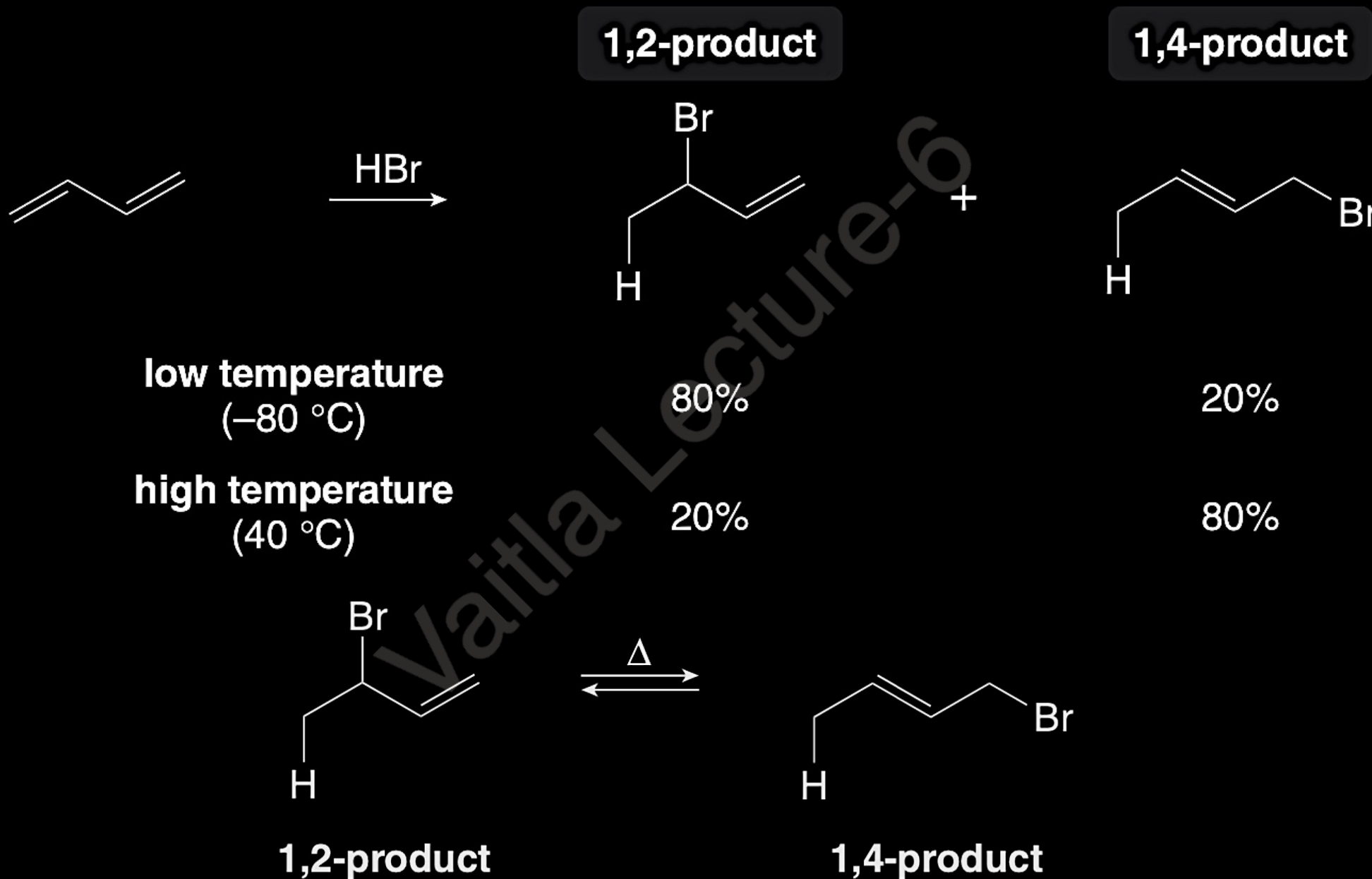


Why Thermodynamic enolate is favorable under these conditions?

greater delocalization of electron density throughout the conjugated system

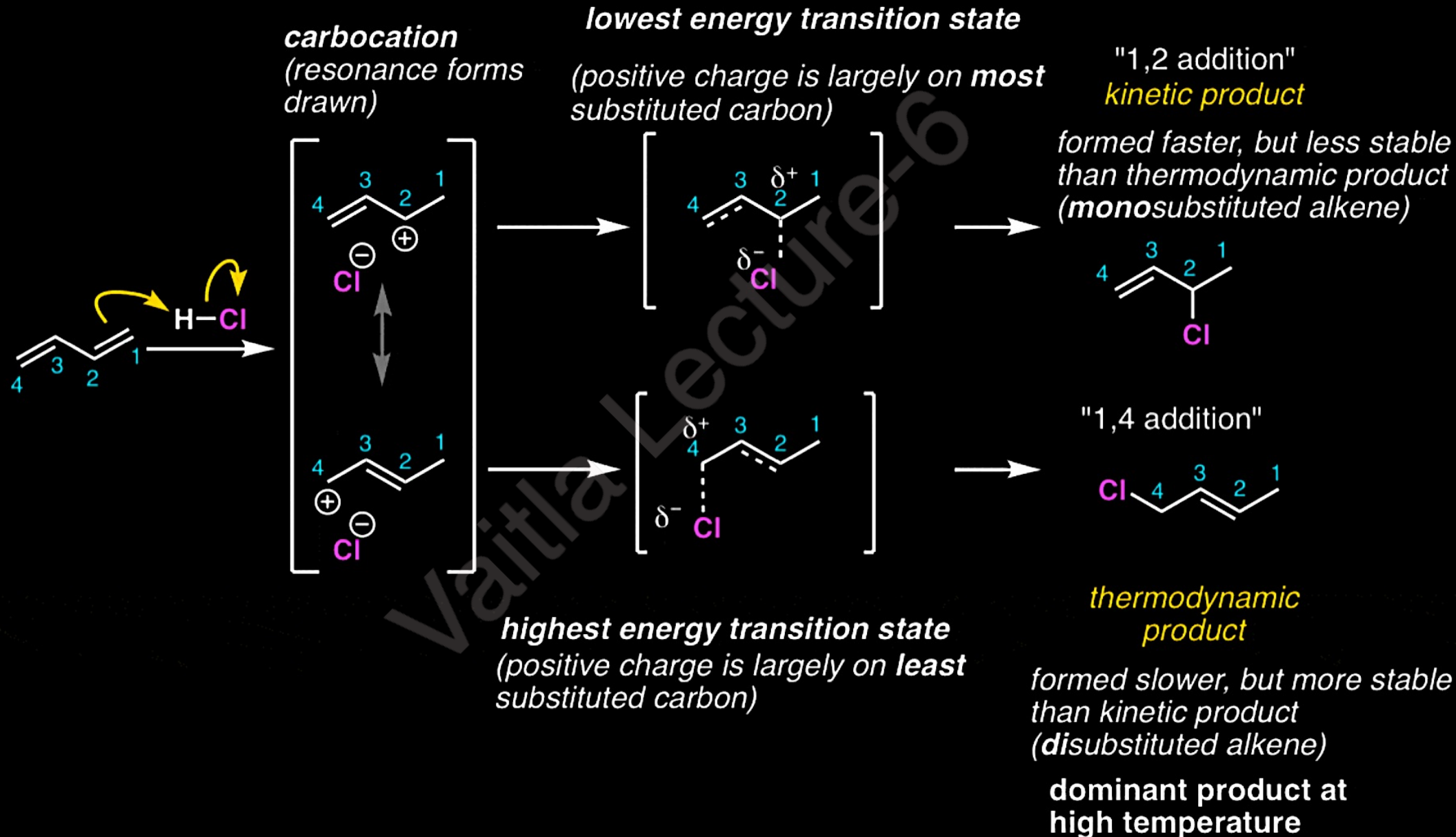
Thermodynamic and kinetic control of a reaction

1,3-Butadiene addition

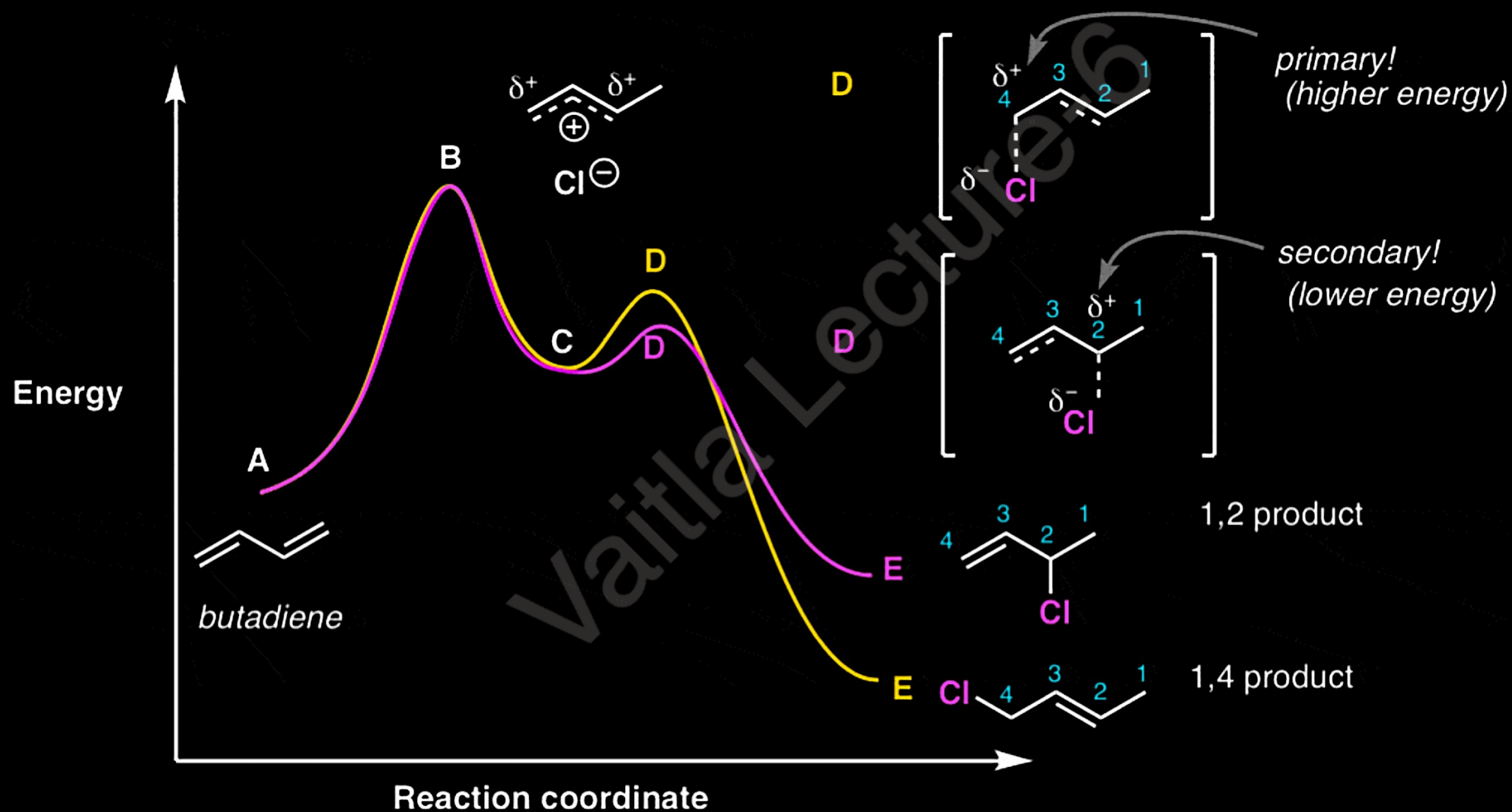


Thermodynamic and kinetic requirements of a reaction

1,3-Butadiene addition

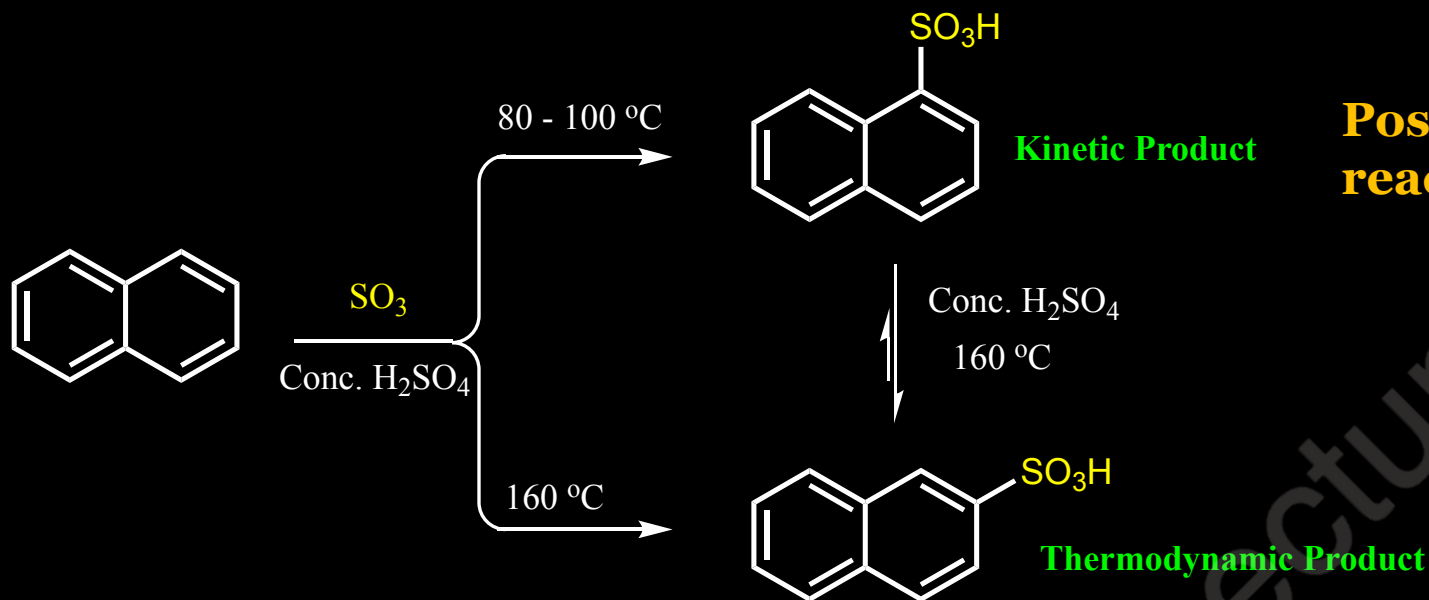


Energy coordinate for 1,2- versus 1,4- additions to butadiene



Thermodynamic and kinetic requirements of a reaction

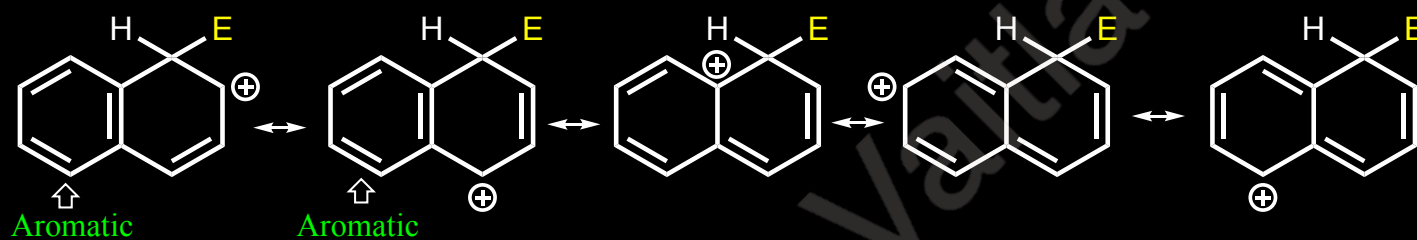
Naphthalene sulfonation



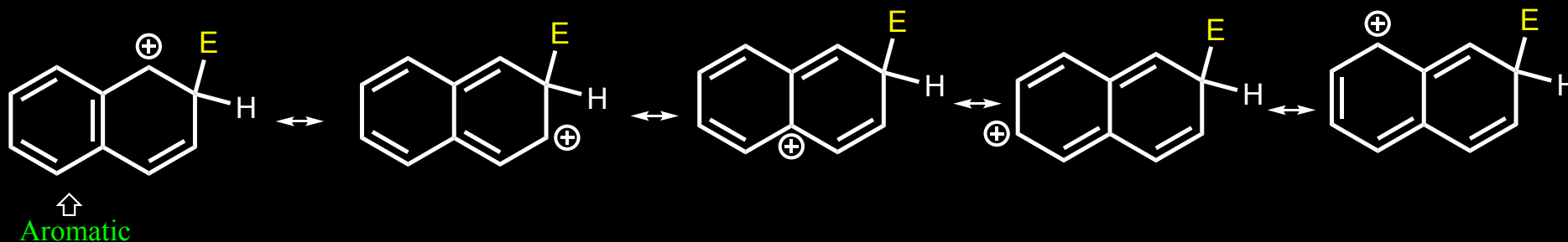
Position 1 is the most reactive in naphthalene.

Why??

Why kinetic product is predominant at low temperature?



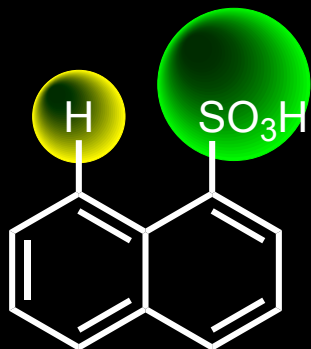
The resonance hybrid of this intermediate is quite aromatic and hence less unstable because it has two resonance forms that keep complete aromaticity of at least one ring.



The resonance hybrid of this intermediate is less aromatic than the previous one and is thus more unstable because it has only one resonance form where the aromaticity of one ring is kept

Naphthalene sulfonation

Why Thermodynamic product is predominant at high temperature?



the substitution at position 1 (*alpha*) yields the most sterically congested product and therefore the least thermodynamically stable one.

Therefore, the substitution product at position 1 (*alpha*) occurs at a fast pace (**kinetic control**). However, in the case of the *reversible* sulfonation, if one lets the reaction proceed during a longer time and at a high temperature, the major product is the 2-substituted one (*beta*; **thermodynamic control**)

