CHEM95002:
Orbitals in Organic Chemistry - Pericyclics

LECTURE 8 *Sigmatropic Rearrangements and Electrocyclic Reactions*

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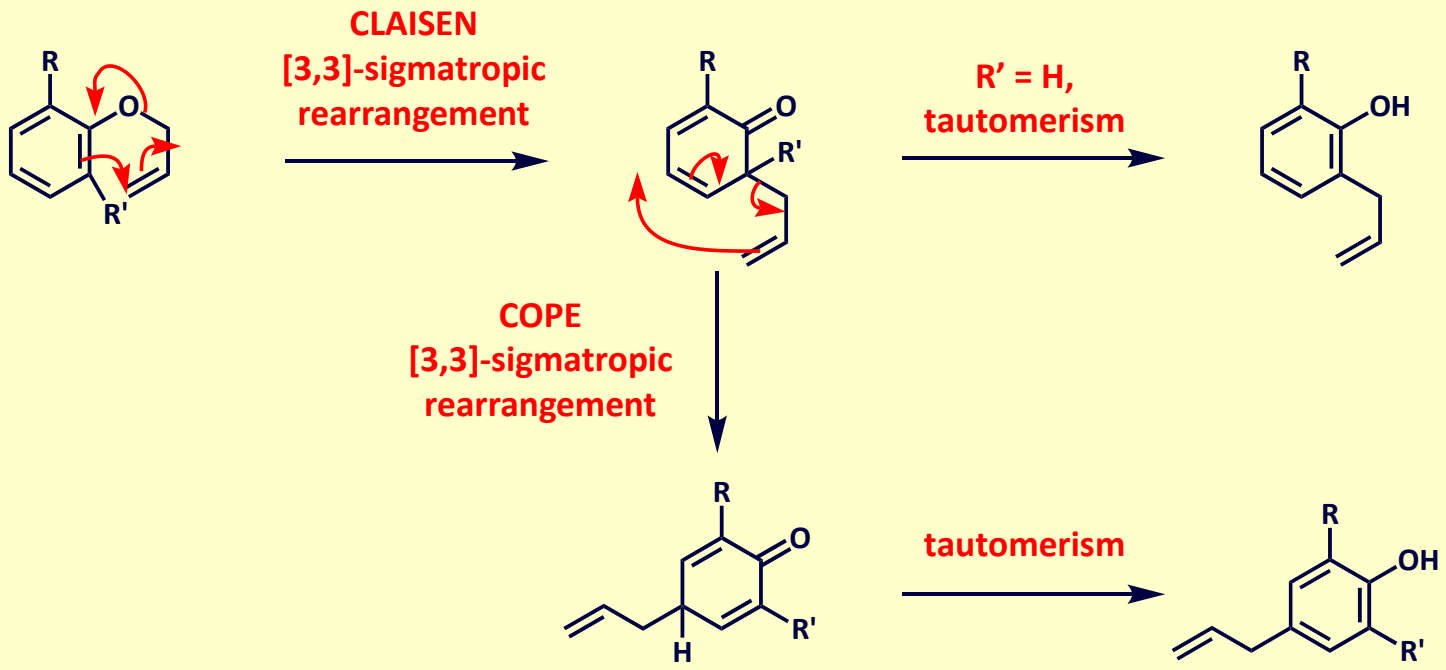
Format & scope of lecture 8

- ***Sigmatropic rearrangements***
  - [3,3]-Cope & oxy-Cope
  - [3,3]-Claisen & variants
  - [1,3]- and [1,5]-Hydride and alkyl shifts
- ***Electrocyclic reactions***
  - Hexatriene
- ***Pericyclic reactions in synthesis***
  - Endiandric acids

Sigmatropic rearrangements

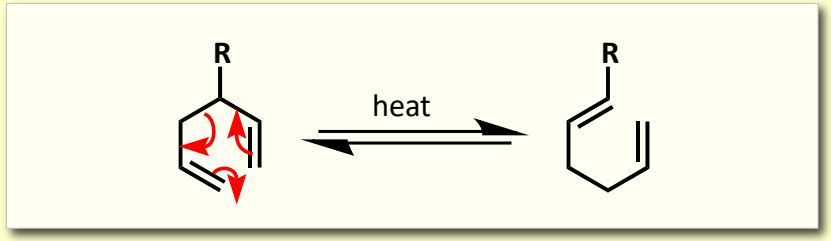
- Synthetically the most important sigmatropic rearrangements are the Cope and Claisen rearrangements. These are both [3,3]-sigmatropic rearrangements.
- The Claisen/Cope rearrangements can proceed *via* chair or boat transition states – the chair transition state is strongly favoured unless there are steric constraints that force a boat transition state.
- Where possible, substituents generally adopt equatorial sites in the chair transition state.



Cope and Oxy-Cope rearrangement

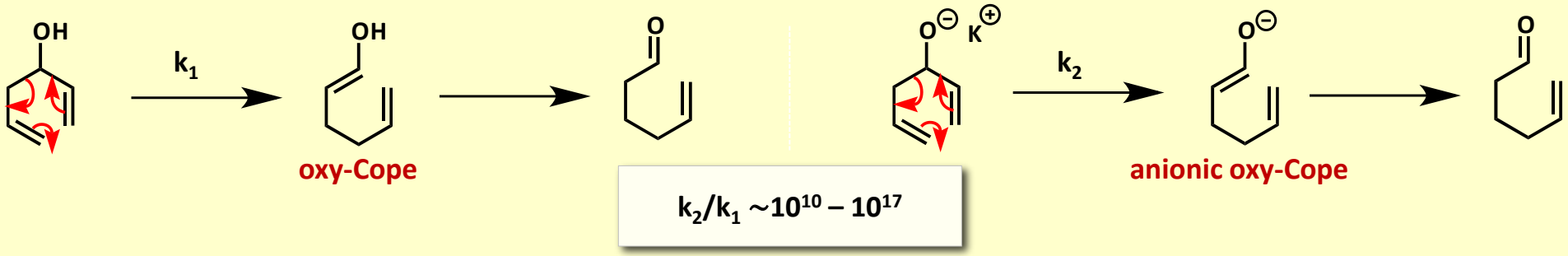
The Cope rearrangement

- high temperatures usually required (>200˚C)

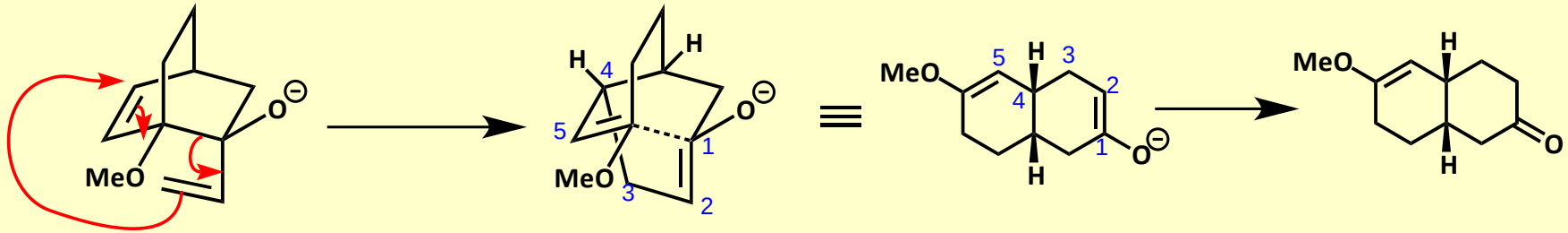


The anionic oxy-Cope rearrengement

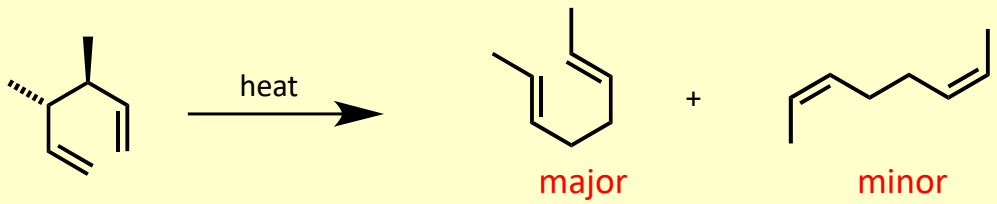
- can be conducted at low temperature (0 °C)

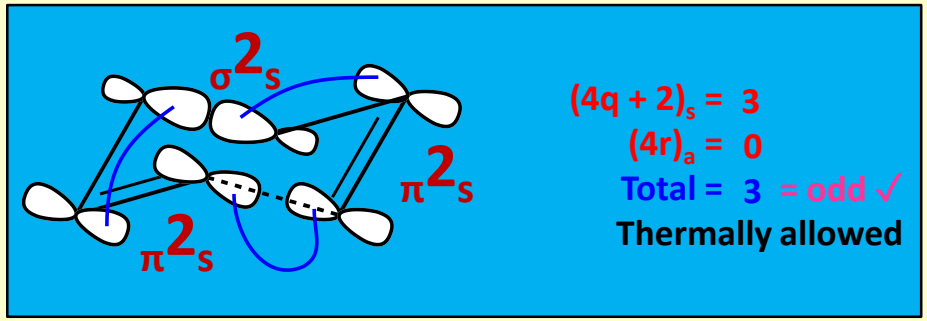


- a useful method for the synthesis of *cis*-decalins from norbornene derivatives…

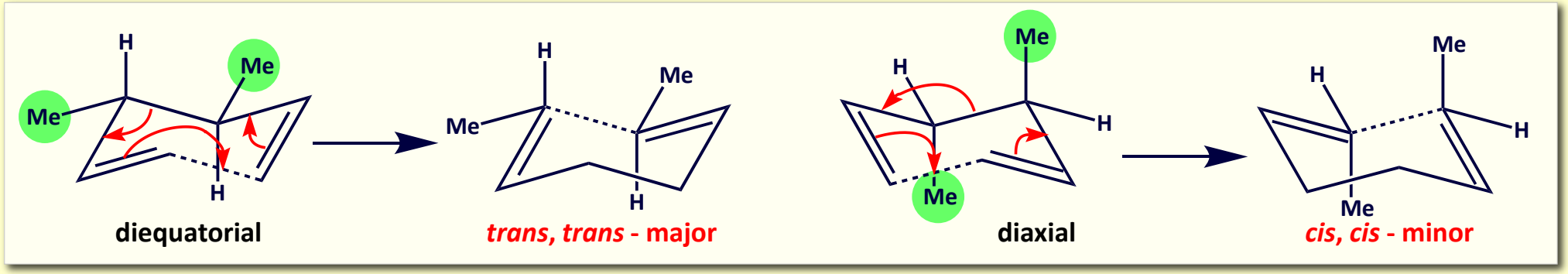


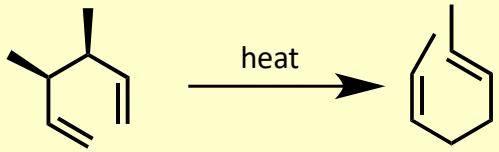
Cope rearrangement

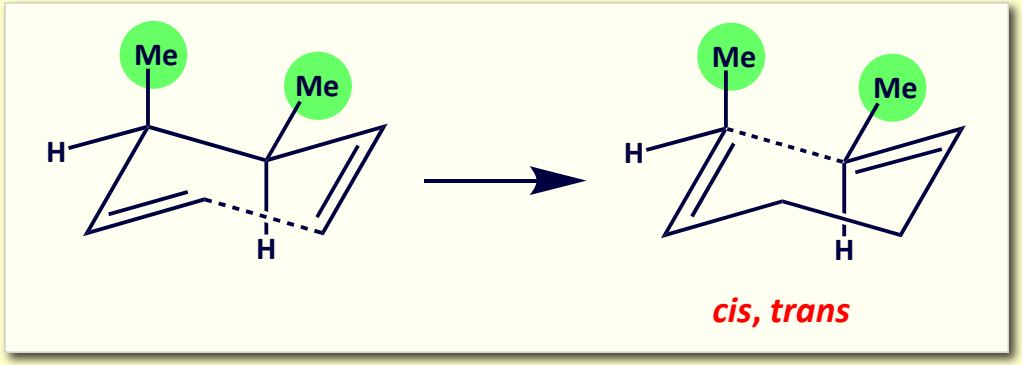




W-H approach





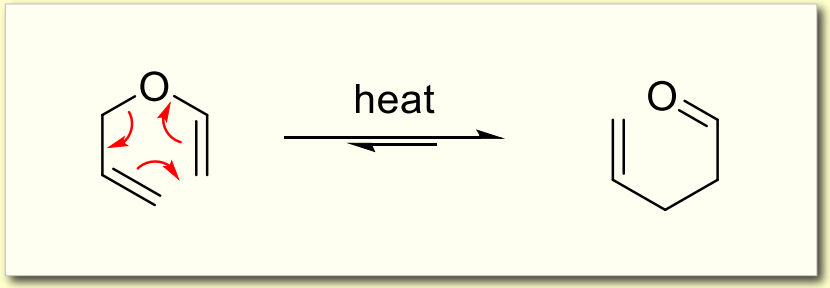


- For an FMO approach see lecture 6, slide 10.

Claisen and variants

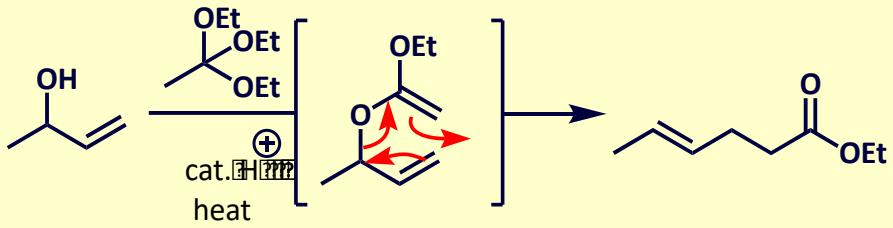
■ ***The Claisen rearrangement***:

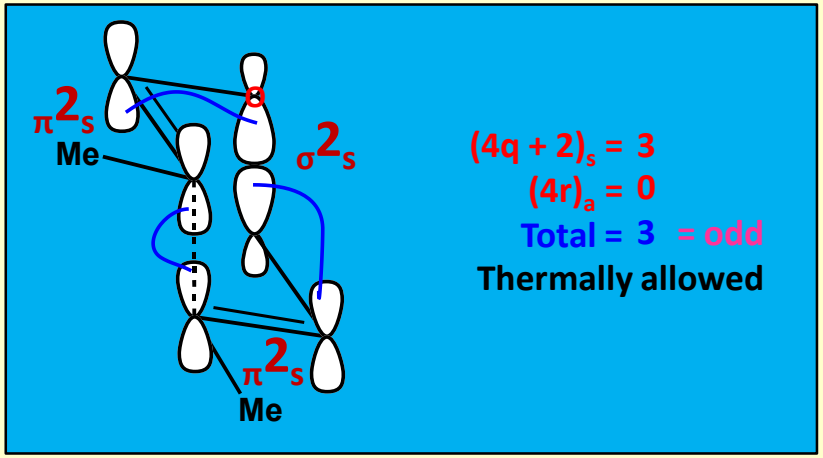
- allyl vinyl ether to γ,δ-unsaturated carbonyl derivative
- driven by formation of C=O bond.



■ ***The Johnson-Claisen rearrangement***

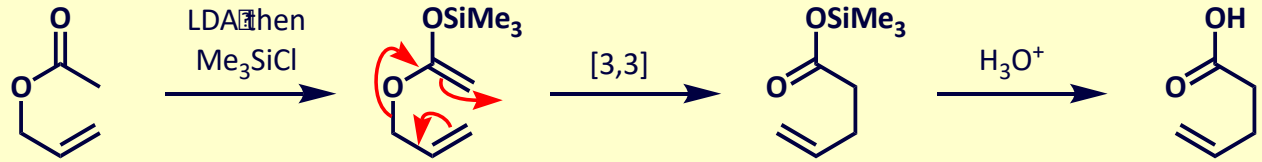
- synthesis of γ,δ-unsaturated esters *via* ketene acetal





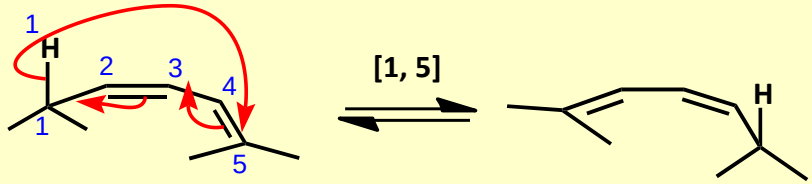
■ ***The Ireland-Claisen rearrangement***

- Synthesis of γ,δ-unsaturated acids *via* silyl ketene acetal

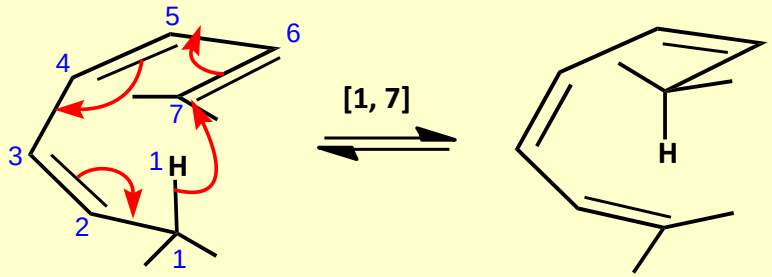


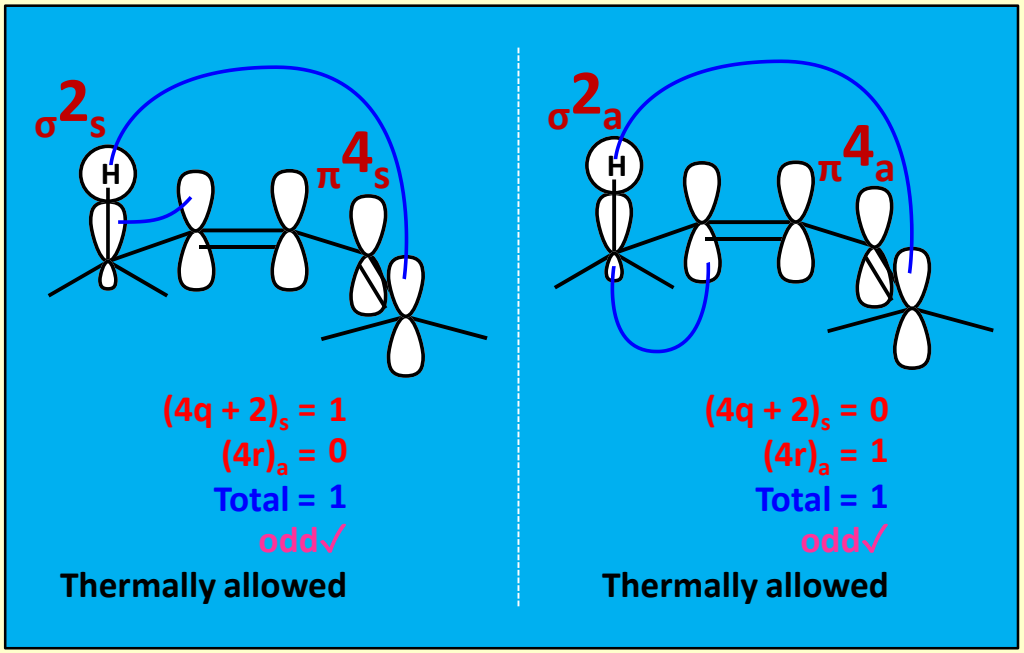
1,n-Hydride shifts

■ A *suprafacial* 1,n-hydride shift involves the hydrogen moving from one end of the conjugated system to the other across one face of the conjugated system

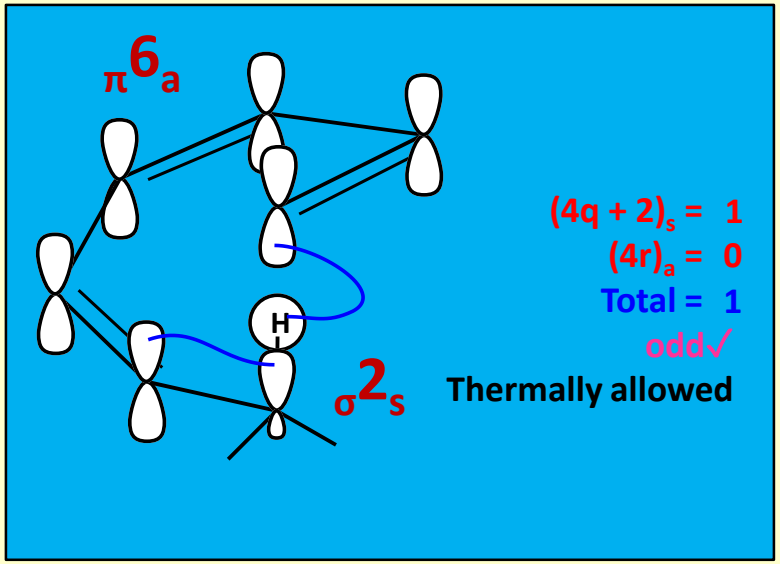


■ An *antarafacial* 1,n-hydride shift involves the hydrogen moving from one end of the conjugated system to the other and moving from one face of the conjugated system to the opposite face





W-H approach

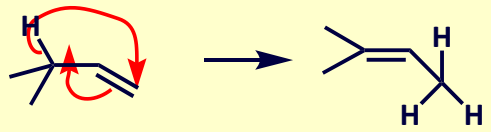


W-H approach

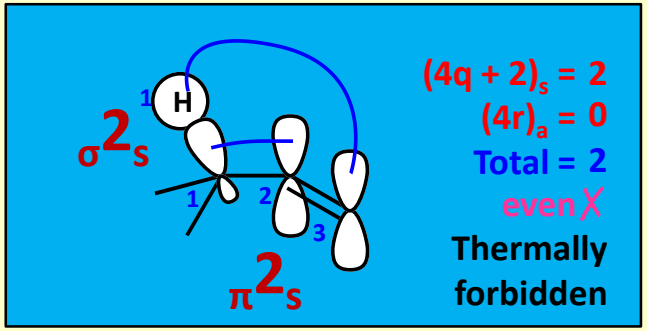
1,3-Hydride and Alkyl shifts

■ ***1,3-Hydride shifts*** **-** do <u>not</u> occur thermally

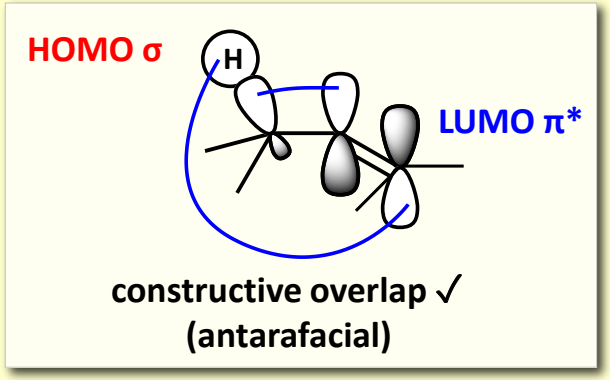
- geometrically reasonable suprafacially, but thermally disallowed
- antarafacially thermally allowed, but geometrically unreasonable:



antarafacial shift allowed
but geometrically unreasonable



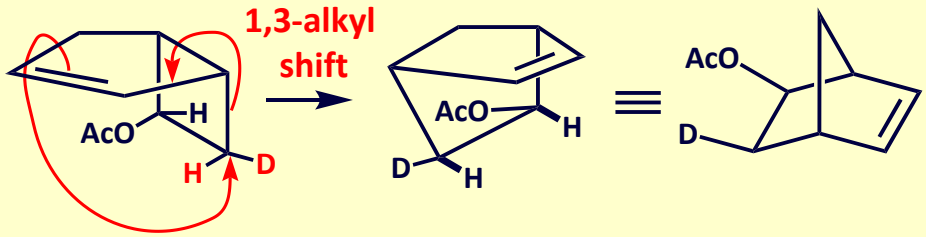
W-H approach

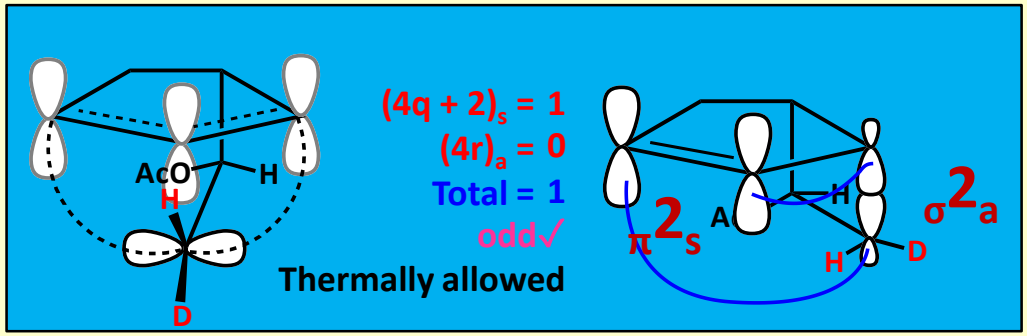


FMO approach

■ ***1,3-Alkyl shifts*** – do occur thermally

- …with *inversion* of configuration in the migrating group:

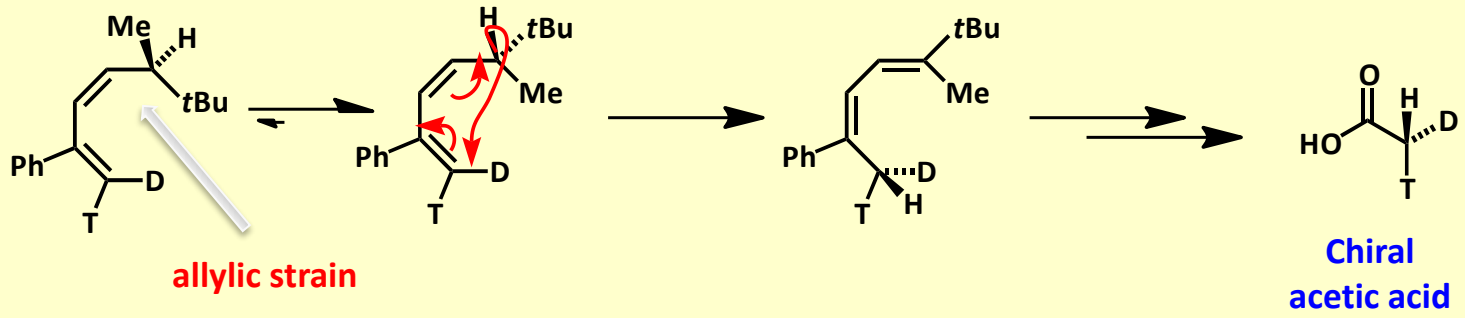


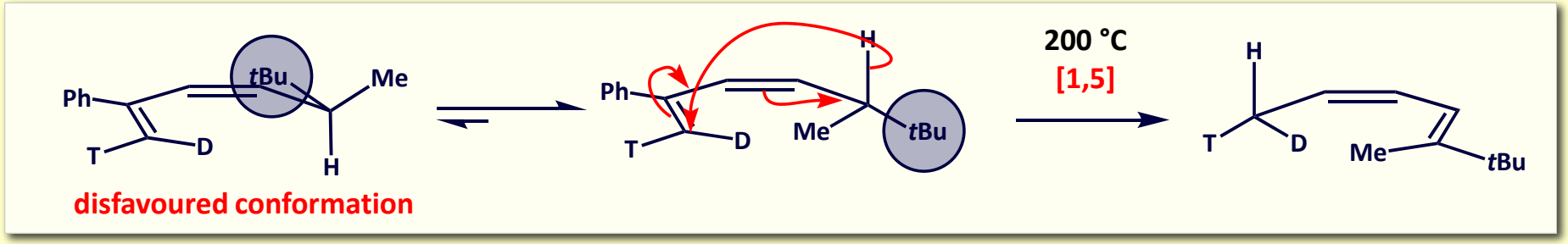


W-H approach

1,5-Hydride and Alkyl shifts

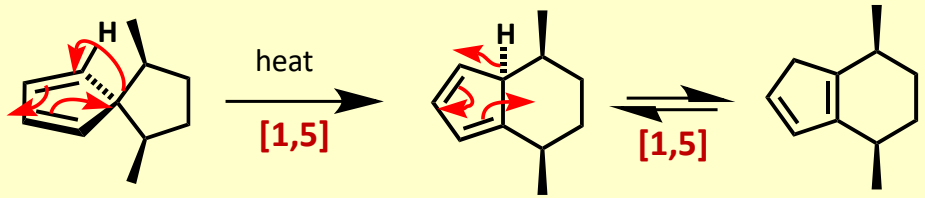
■ ***1,5-Hydride shifts*** – thermally suprafacial reactions:

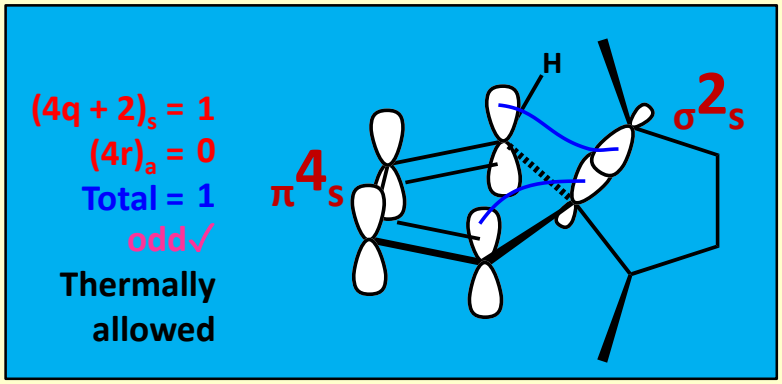




■ ***1,5-Alkyl shifts*** – thermally suprafacial reactions

- …with *retention* of configuration in the migrating group:

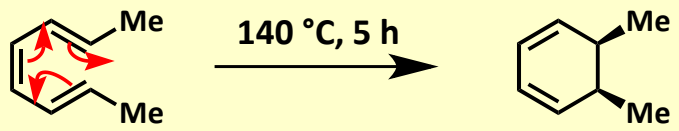


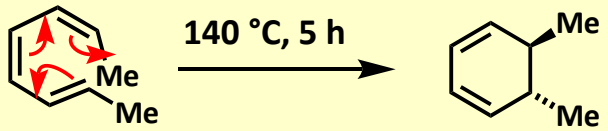


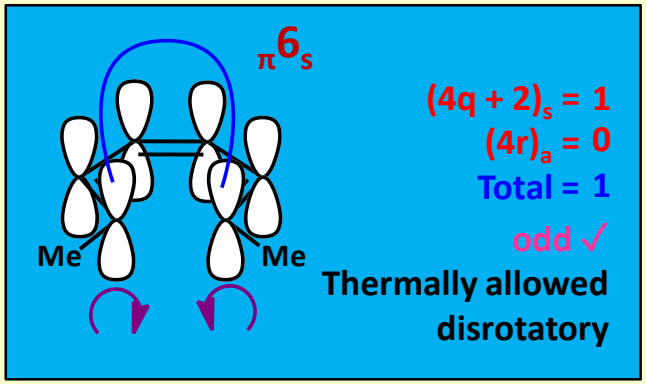
W-H approach

Electrocyclic reactions - *thermal*

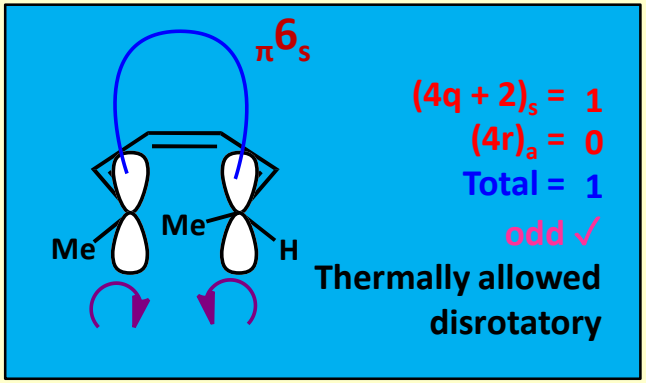
Thermal electrocyclic processes will be *conrotatory* if the total number of electrons is 4n and *disrotatory* if the total number of electrons is (4n +2).
This is reversed for photochemical reactions.







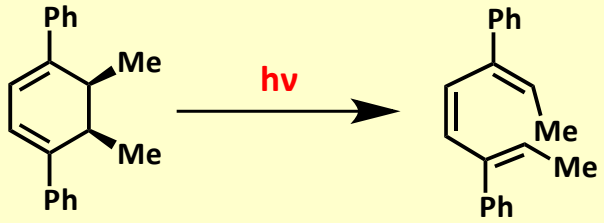
W-H approach

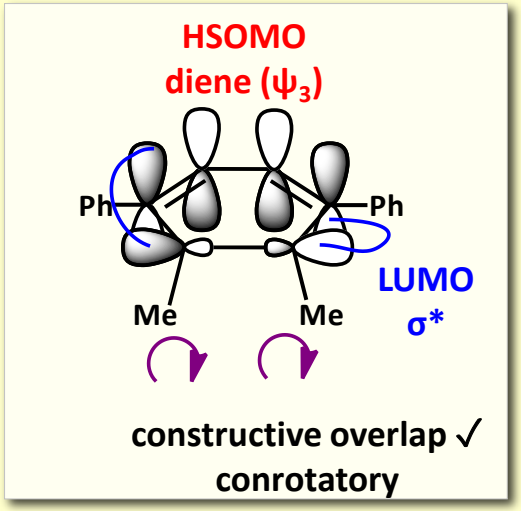


W-H approach

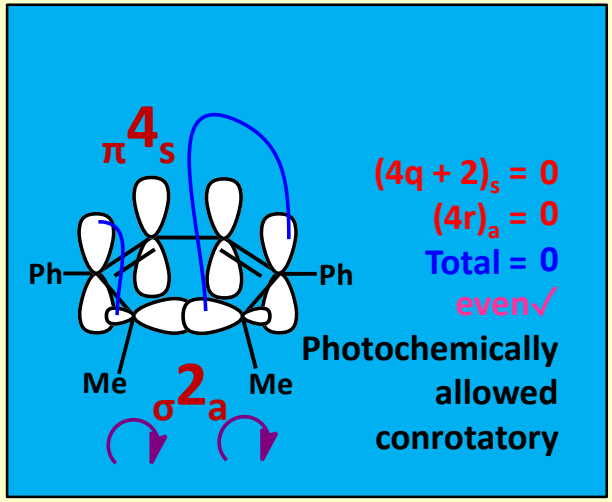
Electrocyclic reactions - *photochemical*

Photochemical electrocyclic processes will be *disrotatory* if the total number of electrons is 4n and *conrotatory* if the total number of electrons is (4n +2).
This is reversed for thermal reactions.



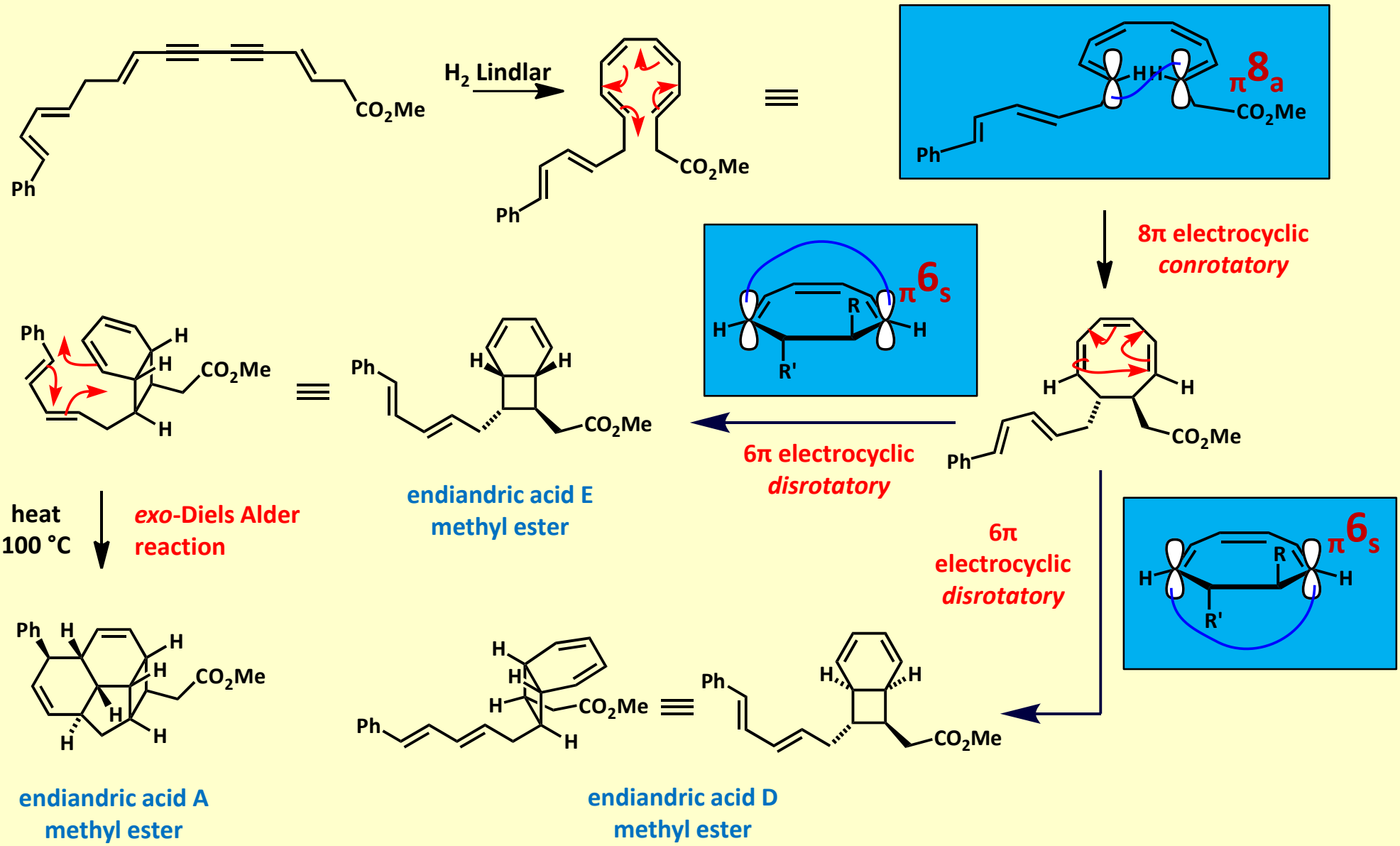


FMO approach



W-H approach

Pericyclics in synthesis: *the endiandric acids*



Nicolaou, *J. Am. Chem. Soc.* **1982**, *104*, 5558 [DOI]