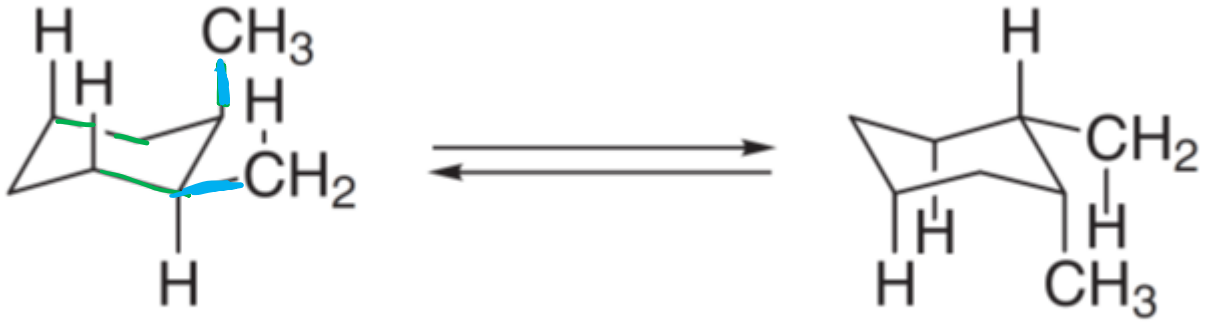
Recap - A-Values

- Free energy difference between equatorial and axial conformer
- 1,3 – Diaxial interactions are a consequence of gauche butane interactions

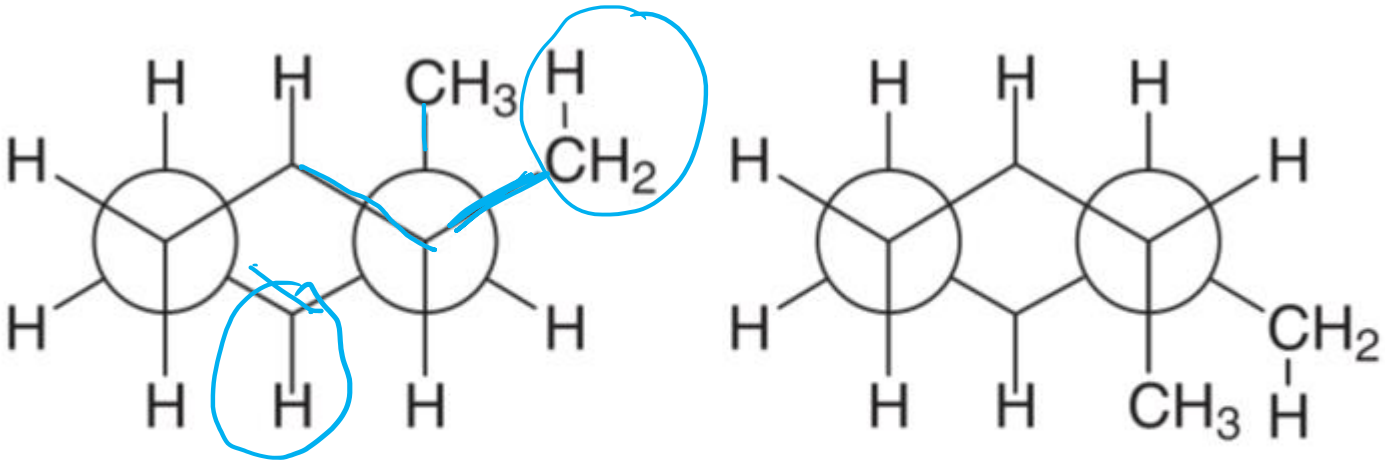
Typical A Values

R	A Value (kcal/mol)		R	A Value (kcal/mol)	
F	0.25	Size vs bond length ↓	CHO	0.6–0.8	
Cl	0.52	ca. 0.5 kcal	$COCH_3$	1.2	
Br	0.5–0.6	ca. 0.5 kcal	CN	0.2	Small, linear groups
I	0.46	ca. 0.5 kcal	C≡CH	0.41	Small, linear groups
OH	0.7 (0.9)	ca. 0.7 kcal (2^{nd} atom effect very small)	NO_2	1.1	
OCH_3	0.75	ca. 0.7 kcal (2^{nd} atom effect very small)	$CH=CH_2$	1.7	
$OCOCH_3$	0.71	ca. 0.7 kcal (2^{nd} atom effect very small)	CH_3	1.8	2^{nd} atom effect very small
NH_2	1.8 (1.4)		CH_2CH_3	1.9 (1.8)	2^{nd} atom effect very small
NR_2	2.1		$^nC_3H_7$	2.1	2^{nd} atom effect very small
CO_2H	1.2 (1.4)		$^nC_4H_9$	2.1	2^{nd} atom effect very small
CO_2Na	2.3		$CH(CH_3)_2$	2.1	2^{nd} atom effect very small
CO_2Et	1.1		$C(CH_3)_3$	>4.5 (ca. 5.4)	
SO_2Ph	2.5		C_6H_5	3.1 (2.9)	

cis-1,2-Dimethylcyclohexane



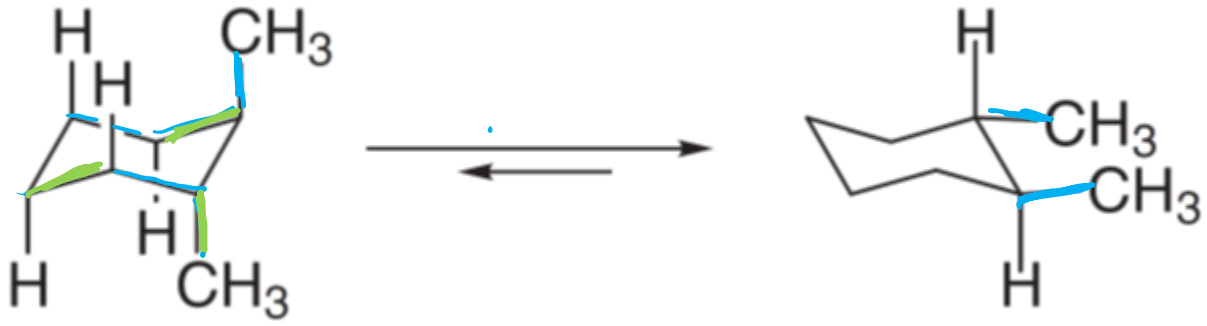
$\Delta E = 0$ kcal/mol



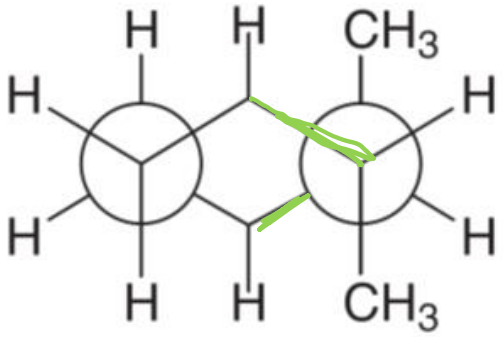
3 × (gauche interaction)
3 × (0.9 kcal) = 2.7 kcal

3 × (gauche interaction)
3 × (0.9 kcal) = 2.7 kcal

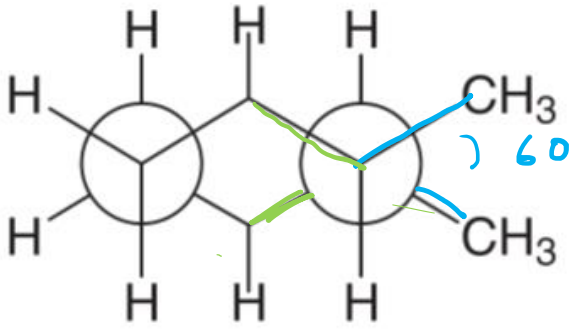
trans-1,2-Dimethylcyclohexane



2.7 kcal/mol more stable



4 × (gauche interaction)
4 × (0.9 kcal) = 3.6 kcal

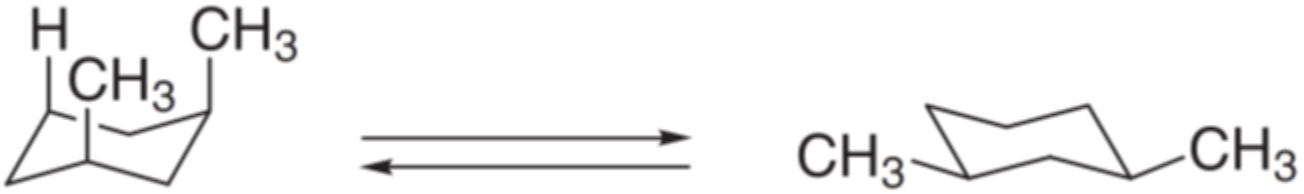


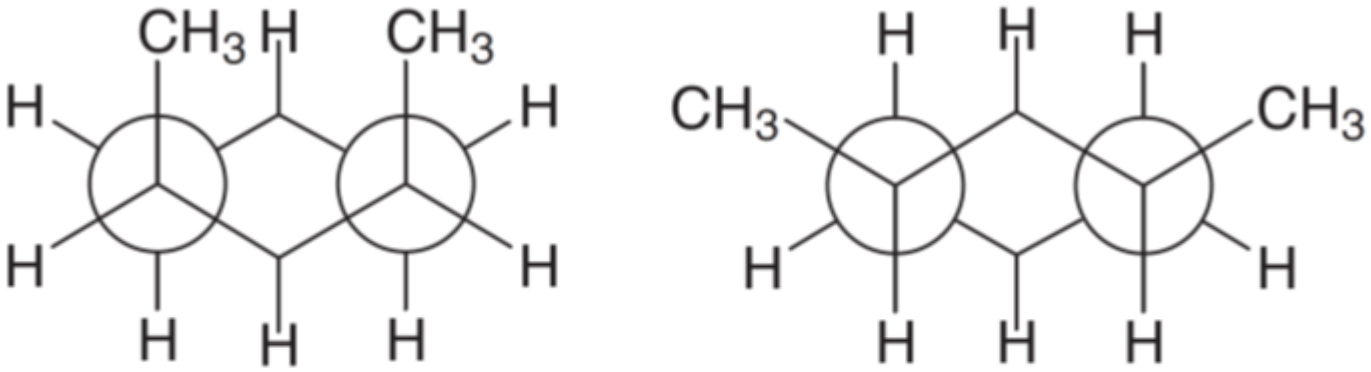
1 × (gauche interaction)
1 × (0.9 kcal) = 0.9 kcal

60°

Butane

cis-1,3-Dimethylcyclohexane



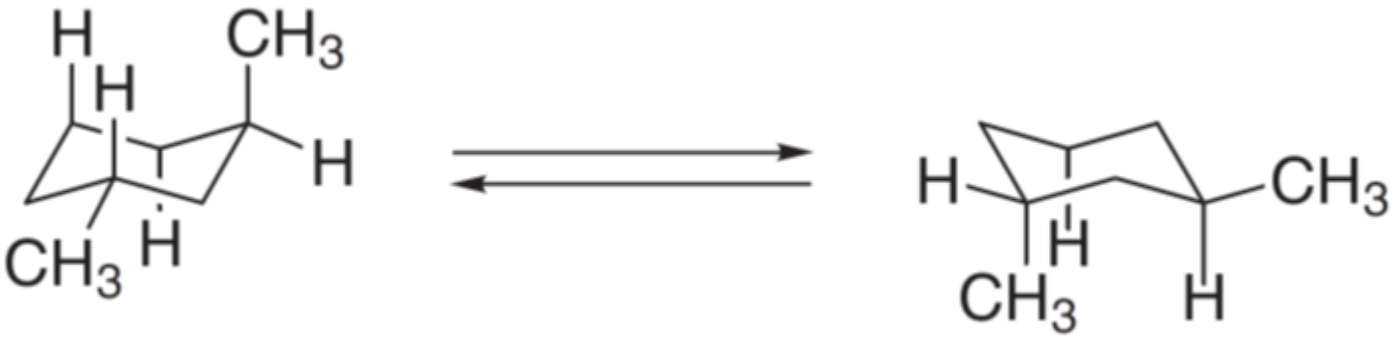


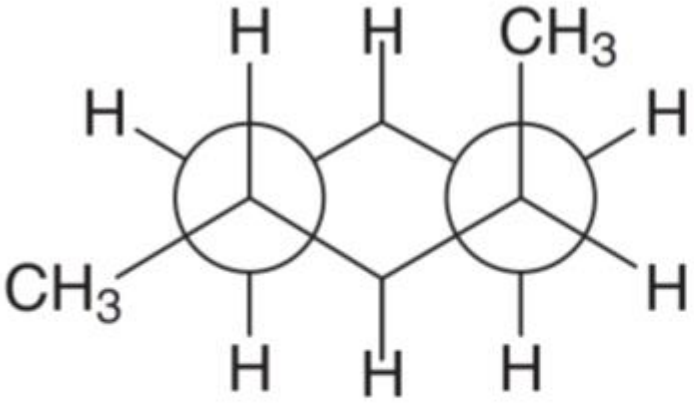
2 × (gauche interaction) +
1 × (Me–Me 1,3 diaxial int)
2 × (0.9 kcal) + 3.7 kcal
= 5.5 kcal

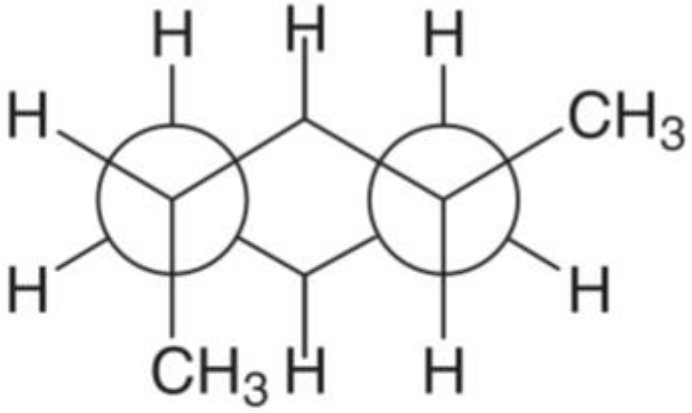
0 × (gauche interaction)
0 × (0.9 kcal) = 0 kcal

Homework: Analysis for *trans*-1,3-dimethylcyclohexane

trans-1,3-Dimethylcyclohexane



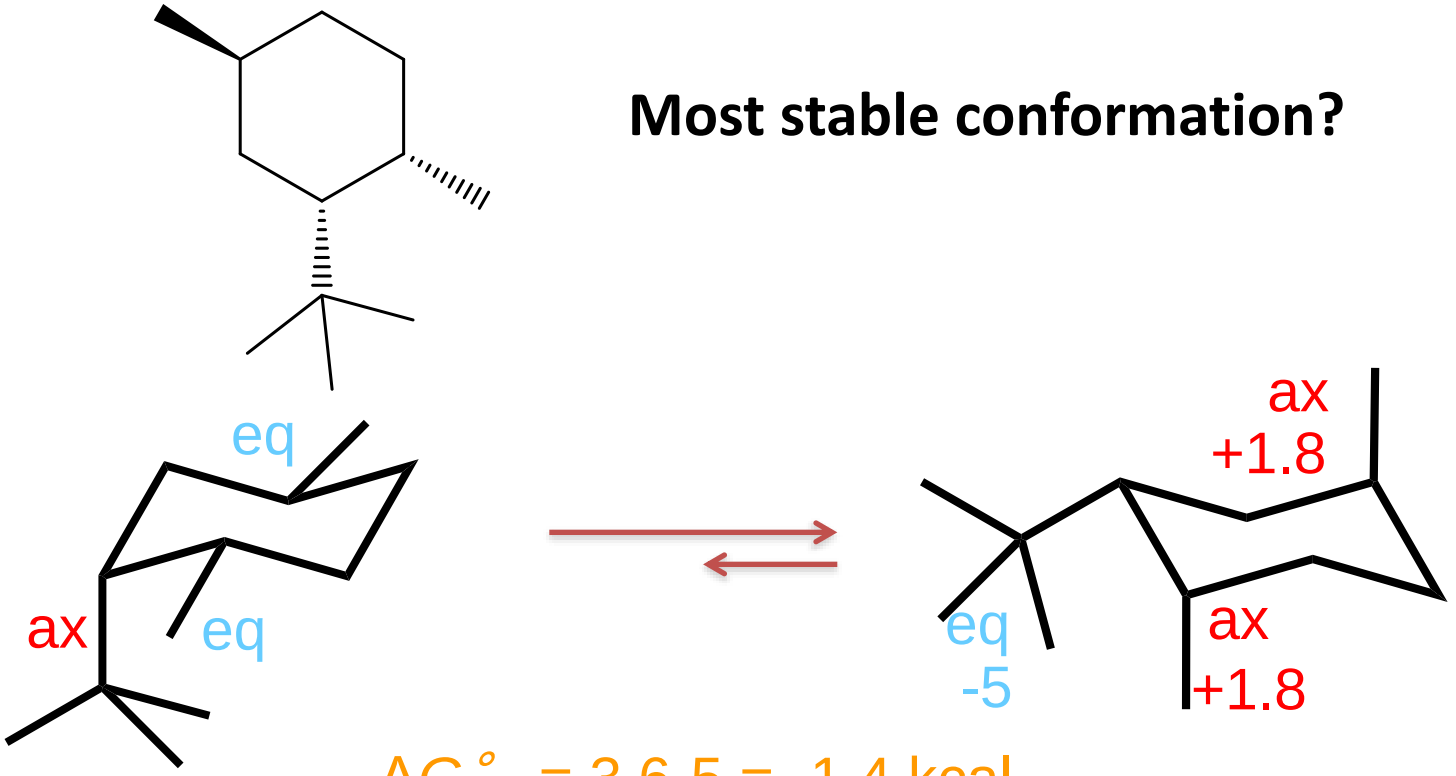




2 × (gauche interaction)
2 × (0.9 kcal) = 1.8 kcal

2 × (gauche interaction)
2 × (0.9 kcal) = 1.8 kcal

Largest Group Biases Conformation



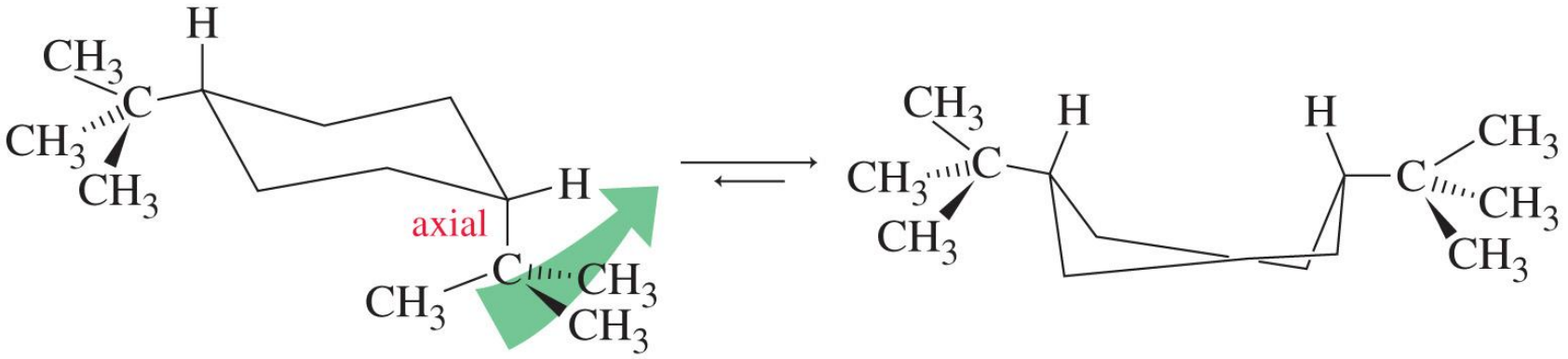
ΔG° = 3.6-5 = -1.4 kcal

Conformation of t-butylcyclohexane is said to be BIASED

But

NOT LOCKED

What about *cis*-1,4-ditertbutylcyclohexane?



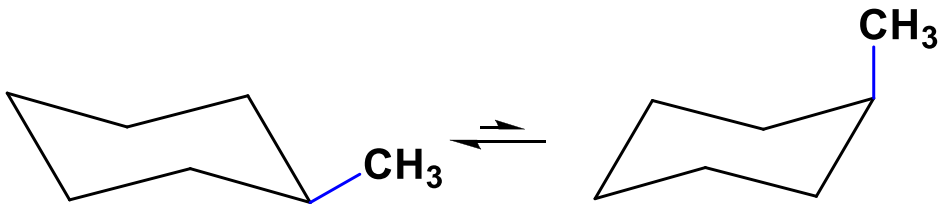
tert-butyl group moves out of the axial position

twist boat

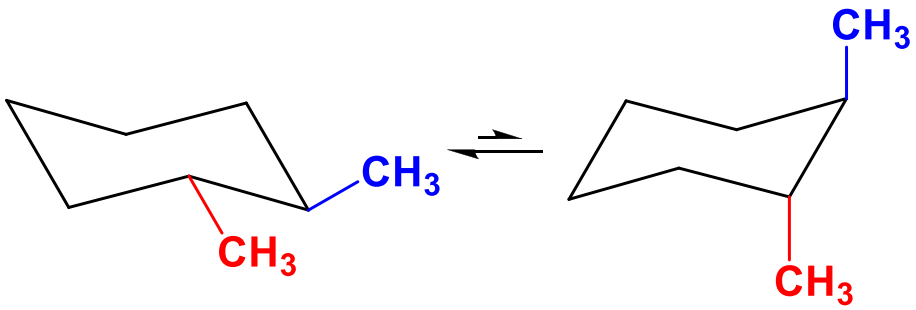
The most stable conformation is the **twist boat**. Both chair conformations require one of the bulky *t*-butyl groups to occupy an axial position.

Points to Remember

(i) Groups which are above the avg. plane would continue to be above the avg. plane even after ring flipping

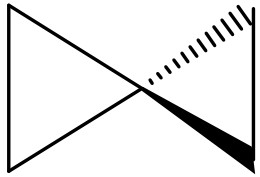


(ii) A *cis*-isomer would remain as *cis*-isomer, so is *trans*

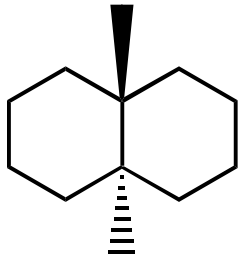


Polycyclic Compounds

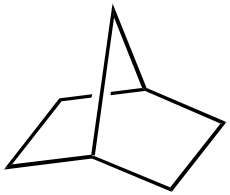
Spiro cyclic compounds: Compounds that share one carbon atom between two rings



Fused ring compounds: Compounds that share two adjacent carbon atoms

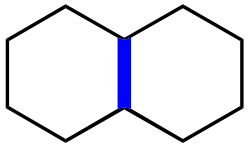


Bicyclic ring compounds: that share two non-adjacent carbon atoms

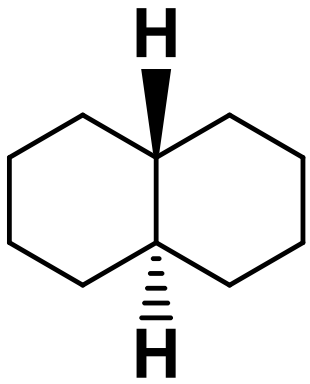


Fused Ring Compounds - Decalins

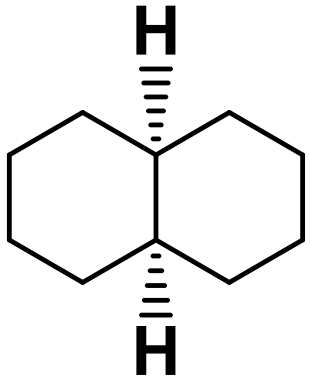
Fused cyclohexane rings which share a common C-C bond



Depending on the orientation of the hydrogen atoms at the ring junction there are two stereoisomers for decalins

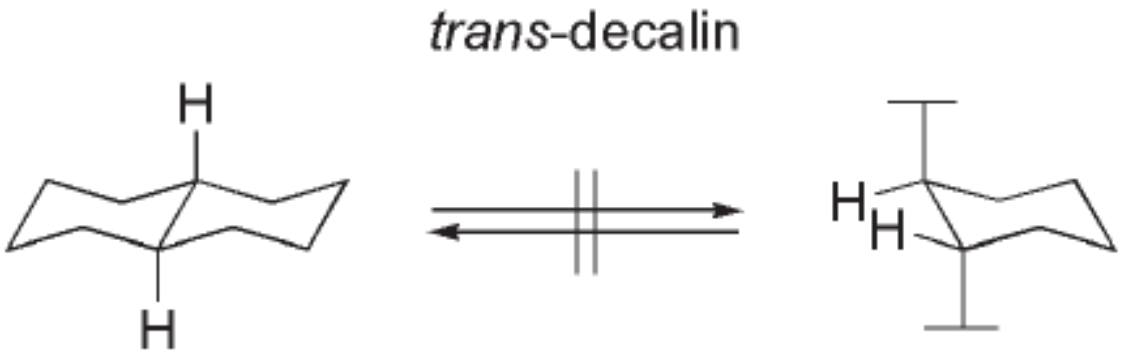


***trans*-Decalin**

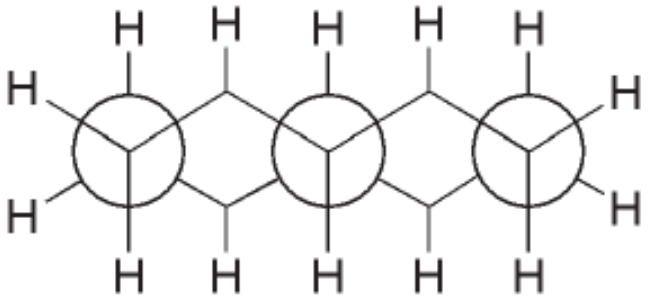


***cis*-Decalin**

trans-Decalin



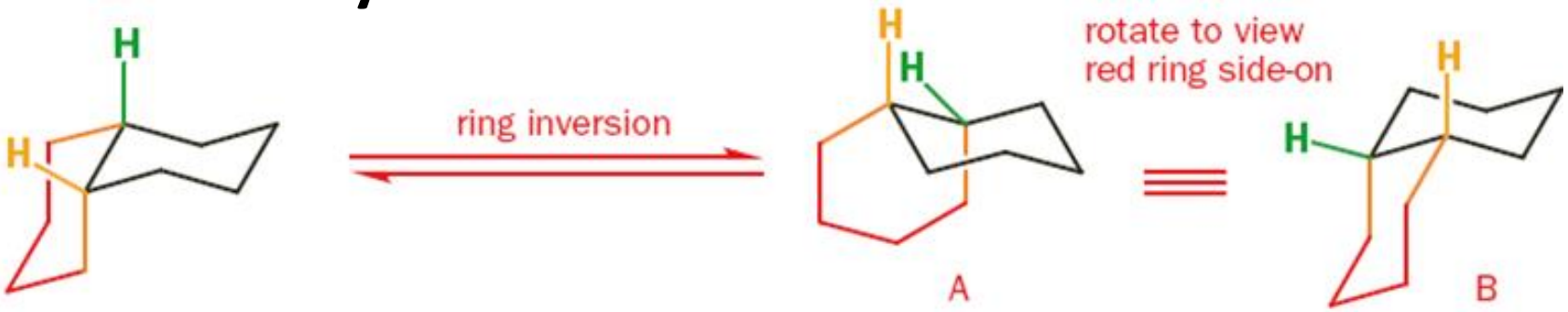
trans-decalins are **conformationally LOCKED** as they cannot undergo ring flipping.



How many destabilizing interactions?

cis-Decalin

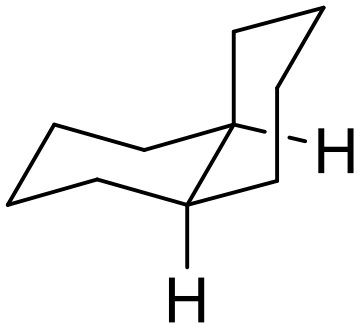
Conformationally flexible!

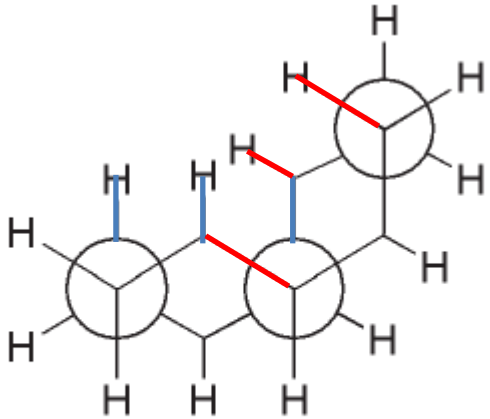


green H starts axial on black ring
yellow H starts equatorial on black ring

after ring inversion,
green H is equatorial on black ring
yellow H is axial on black ring

http://classes.yale.edu/chem220/STUDYAIDS/movies/decalins.html





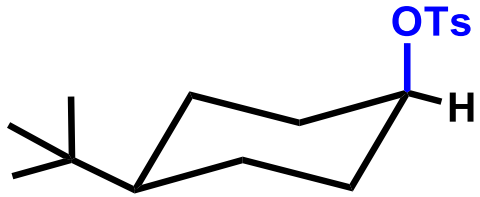
How many destabilizing interactions?

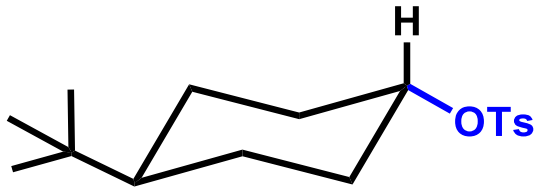
ΔE between *cis*- and *trans*-decalin = 2.7 kcal/mol

Conformations & Reactivity

Reactions of axial and equatorial substituents could be very different!

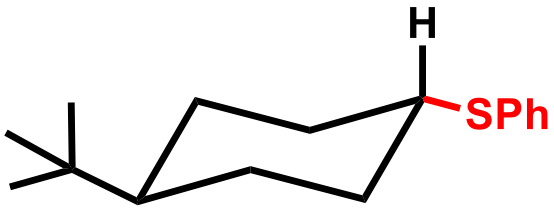
cis

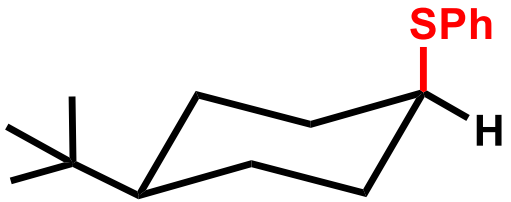




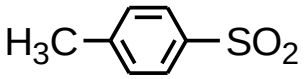
trans

PhS^- PhS^-



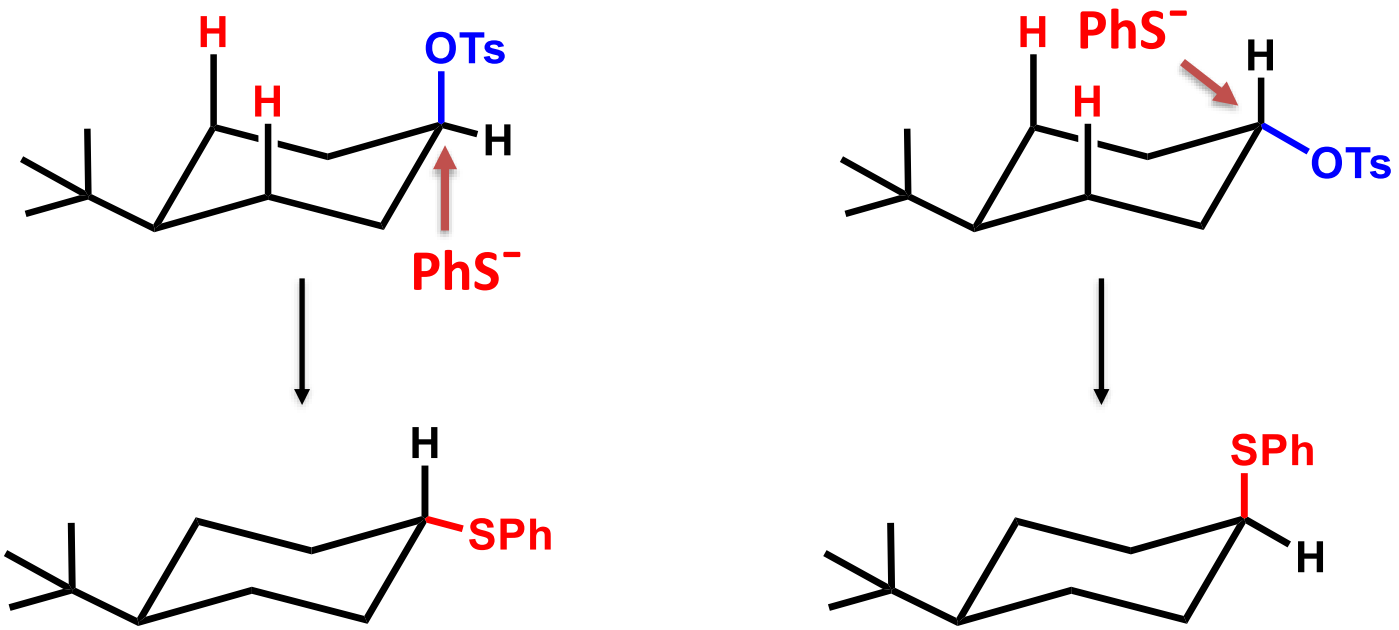


***cis*-compound reacts 31 times faster!! Why???**

Ts = *p*-toluene sulphonyl 

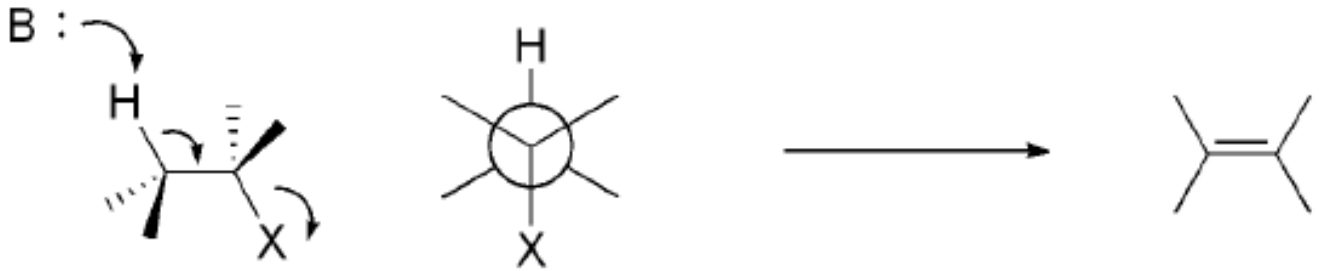
Understanding Selectivity

Hint: This is an S_N2 reaction – Back side attack is favoured



Why is backside attack required for S_N2 reaction?

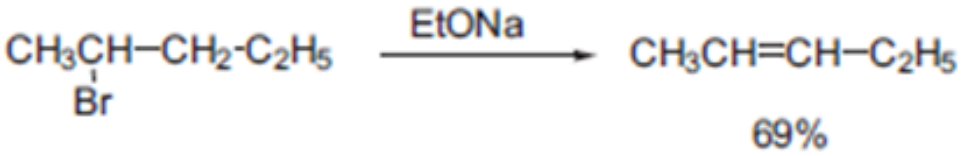
Conformation and Elimination



E2 elimination

Antiperiplanar conformation is required for E2 Elimination. Why?

Homework – Problem 1



Which isomer will be formed more?

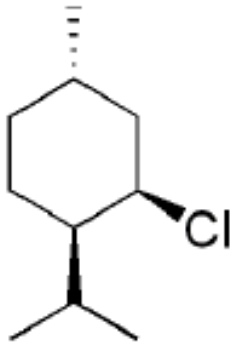
Draw the Newman projection of the starting material to determine conformation required for cis and trans product.

Br/Et gauche interactions = 0.5 kcal

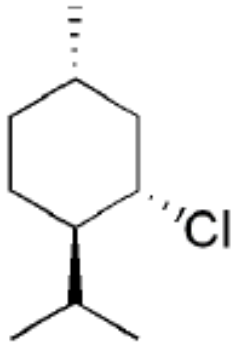
Et/Me gauche interactions = 0.9 kcal

Homework Problem 2

Consider E2 elimination of



neomenthyl chloride

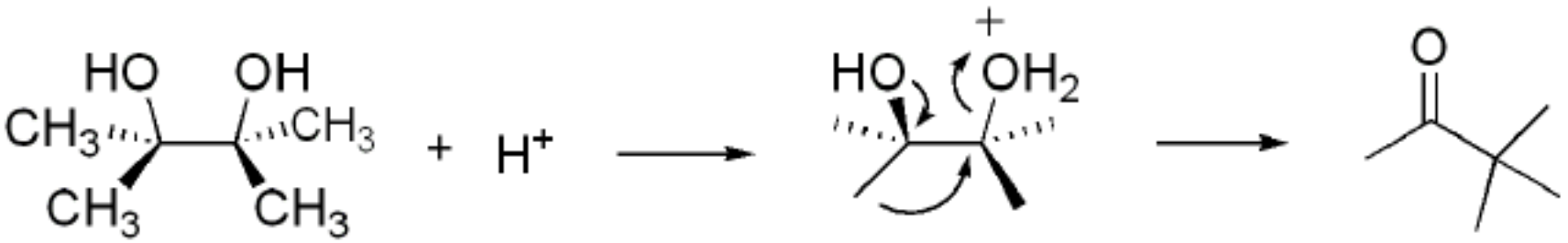


menthyl chloride

Which of these react faster?

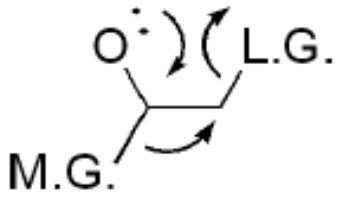
Do both give the same product?

Rearrangement Reactions



pinacolone

heteroatom



migrating group

leaving group

$-OH_2^+$

$-OSO_2R$

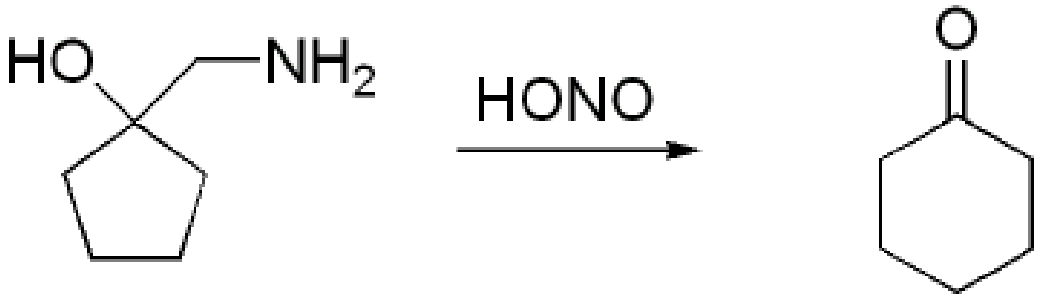
$-N_2^+$ diazonium ion

- This process is conformationally dependent!

Migrating group antiperiplanar to leaving group.
Why?

Homework Problem - 3

Ring expansion of cyclic β-amino alcohols



Explain this observation