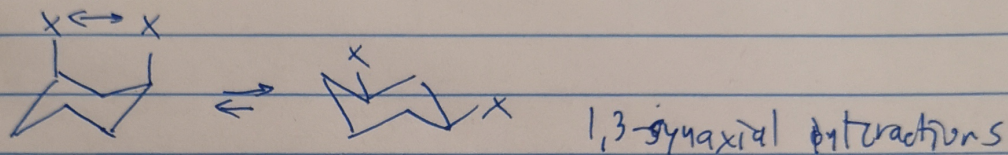


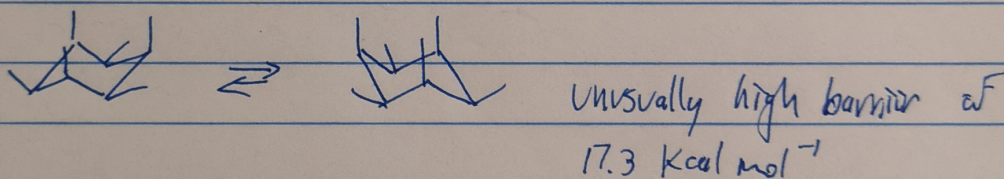
## Lecture XXI: Cyclohexane Conformations, continued

03-23-2020

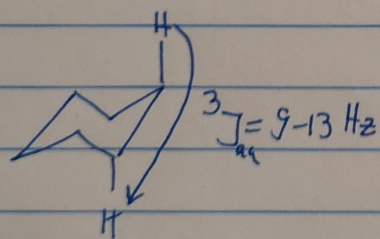
Last time, we finished with discussions of deviations from additivity for  $A$  values. Generally, if you have 1,3-diaxial substituents, these will be quite large:



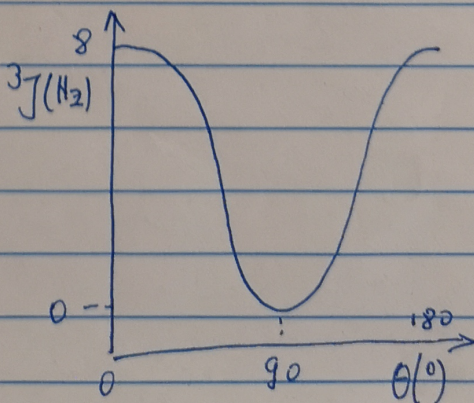
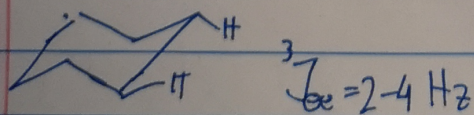
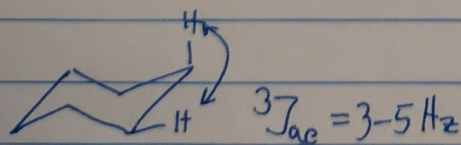
|                           |                            |                         |              |
|---------------------------|----------------------------|-------------------------|--------------|
| $\text{CH}_3\text{-CH}_3$ | 3.7 kcal mol <sup>-1</sup> | $\text{CN/CN}$          | 3.0 kcal/mol |
| $\text{OH}_3/\text{OH}$   | 2.4 " "                    | $\text{CH}_3/\text{Ph}$ | 3.4 " "      |
| $\text{CH}_3/\text{F}$    | 0.4 " "                    |                         |              |



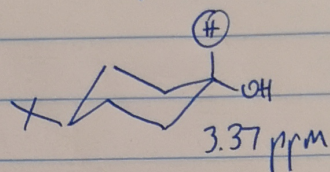
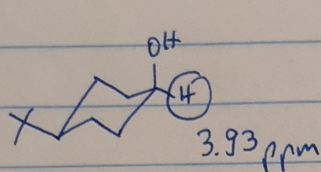
## Experimental differences between axial and equatorial protons



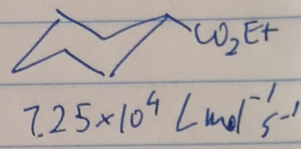
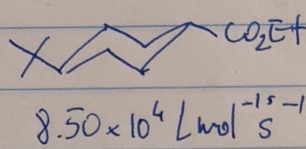
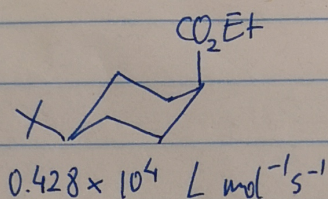
Karplus relationship:



Axial protons generally resonate upfield from equatorial ones too.

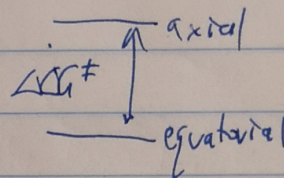
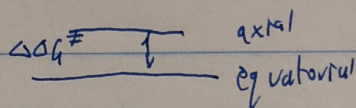


Reactivity differences between conformers:



rate of ester hydrolysis

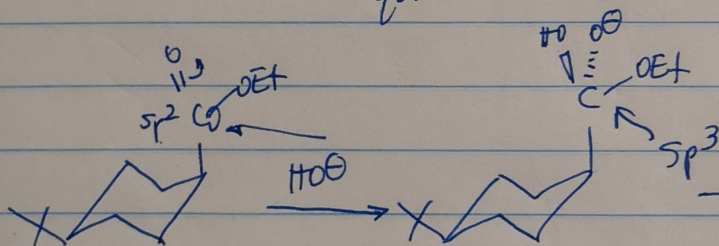
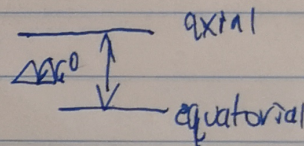
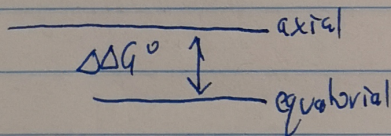
transition state



$\Delta\Delta G^\ddagger < \Delta\Delta G^0$  steric assistance

$\Delta\Delta G^\ddagger > \Delta\Delta G^0$  steric hindrance

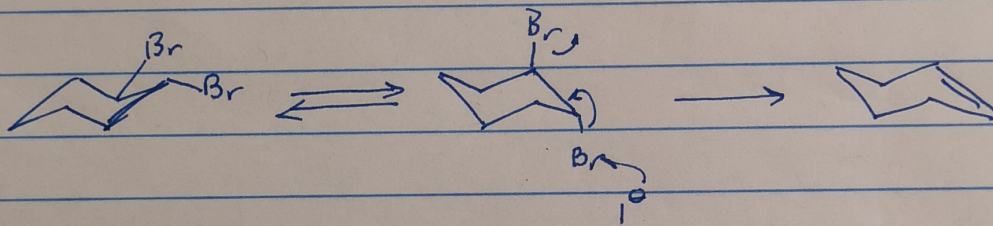
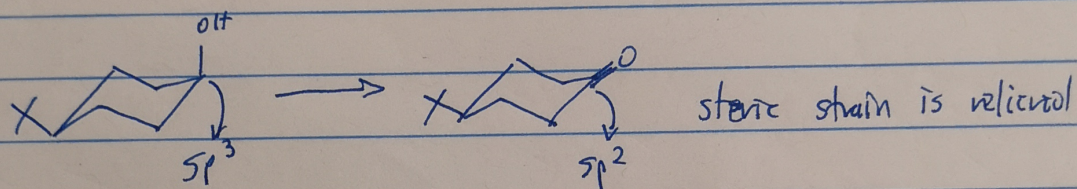
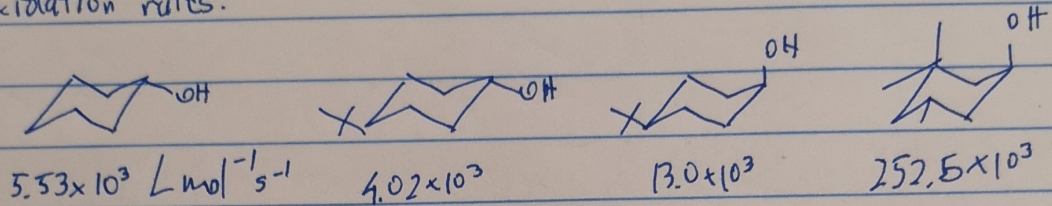
Ground state



- $sp^3$  carbon cannot turn away from this ring and is therefore more bulky
- anionic group is better solvated, and in the transition state it appears bulkier

Steric assistance:

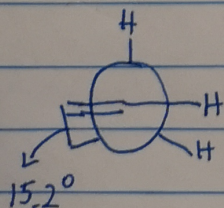
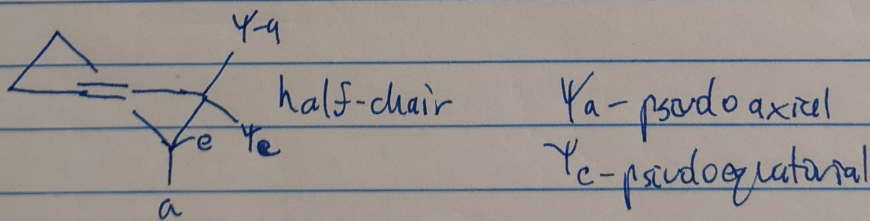
Oxidation rates:



in some cases, diaxial relationship is required

How about other six-membered rings?

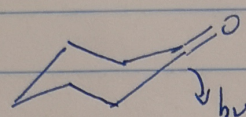
Cyclohexene



is nonplanar

is planar

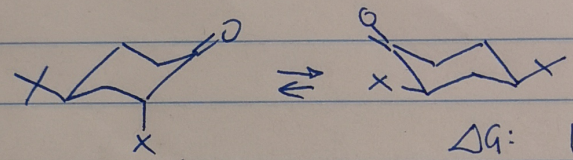
Cyclohexanone



but flattened at this carbon atom

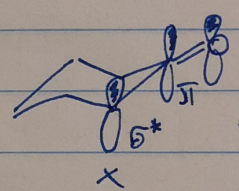
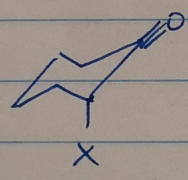
Cyclohexanone is slightly strained (~3 kcal/mol)

Its reduction with NaBH<sub>4</sub> is about 355 times faster than that of



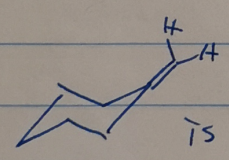
|             |      |      |       |       |
|-------------|------|------|-------|-------|
| $\Delta G:$ | 1.56 | 1.09 | -0.68 | -1.03 |
| (kcal/mol)  | Me   | Et   | Cl    | Br    |

axial isomer is preferred



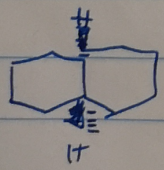
} better orbital alignment

Equatorial X cannot do it

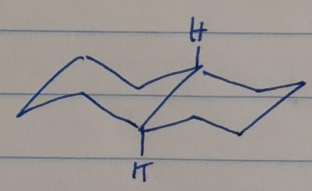


is similar in structure to cyclohexanone

Polycyclic compounds

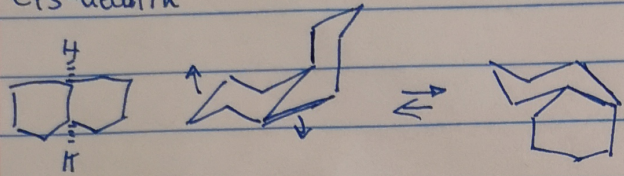


trans-decalin



Cannot chair-flip

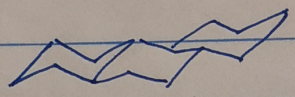
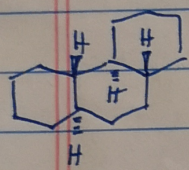
cis-decalin



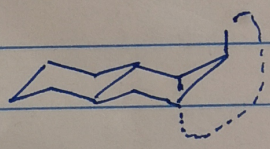
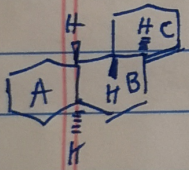
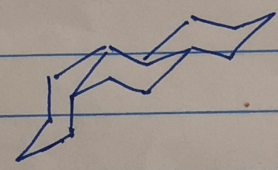
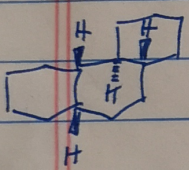
mirror image of the original form

axial and equatorial protons interconvert

Perhydrophenanthrene

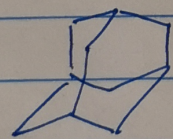


all-chairs

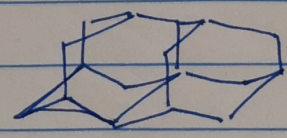


-very strained, therefore B ring is probably not a chair

In fused systems, strain is easily introduced, but many of them can be completely strain-free:



adamantane and diamantane are good examples.



one example

Next time, we will examine heterocycles and different ring sizes.