







## What you need to know

Important concept → Energy and stability are relative terms that are related to each other → "relative" because they need comparisons to make sense

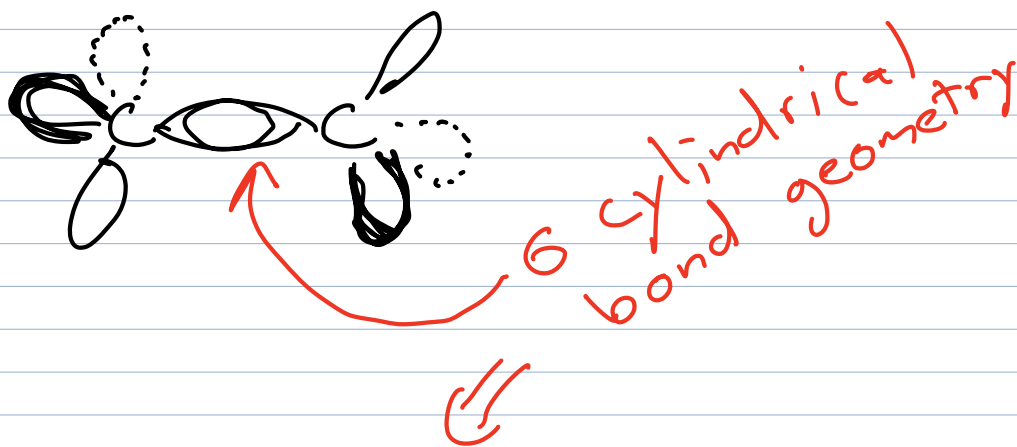
A molecule with higher energy is less stable

A molecule with lower energy is more stable

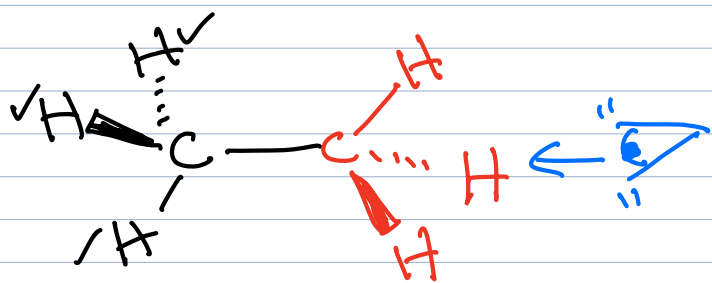
Strain in molecules raises energy and decreases stability

⇒ Molecules are found predominantly in their lowest energy (most stable) form.

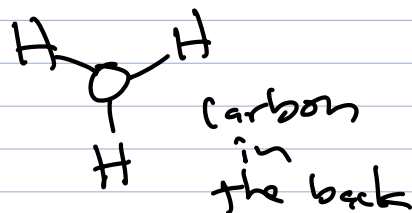
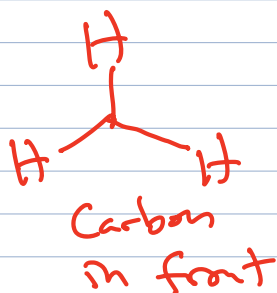
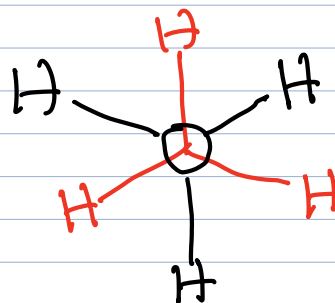
Carbon-Carbon sigma bonds rotate rapidly at room temperature



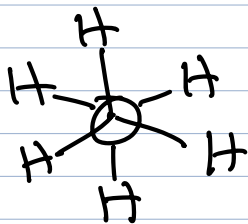
It does not get weaker as the bond rotates



Newman Projection



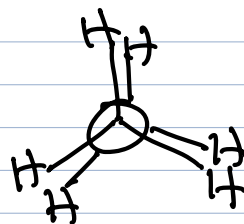
Two extremes



Staggered  
Conformation



More stable  
Minimal torsional  
strain



Eclipsed  
Conformation



Less stable  
Torsional  
strain is  
present

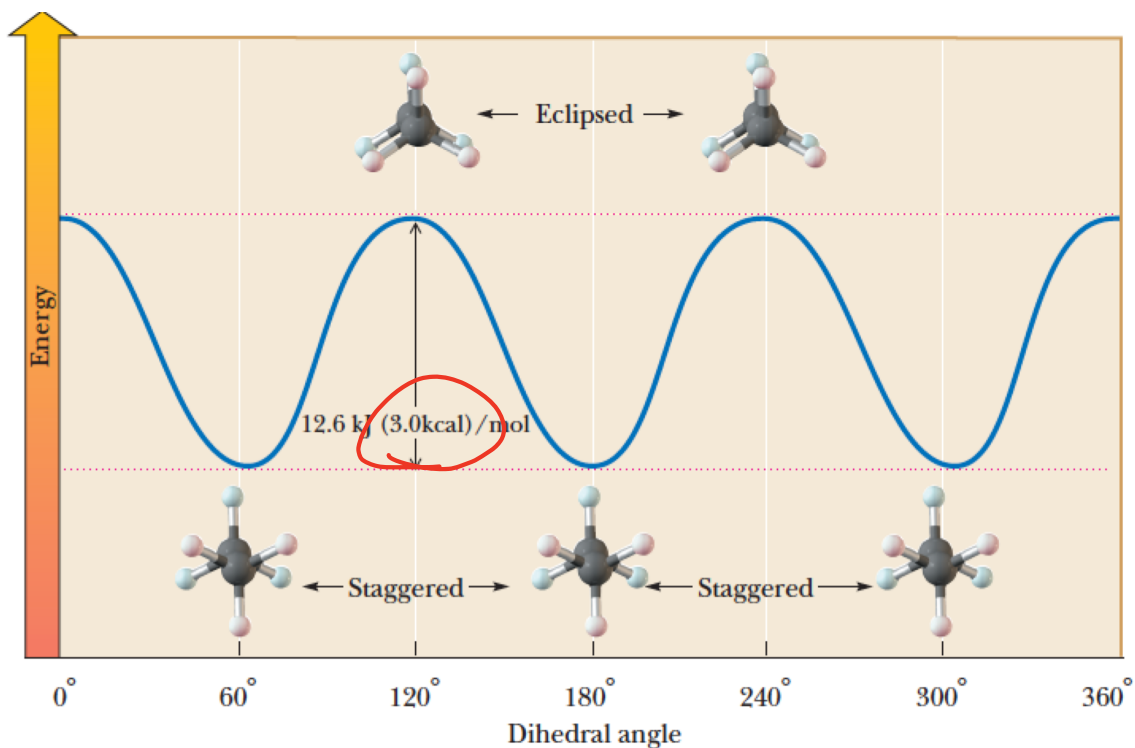
Torsional strain  $\rightarrow$  a complex effect  
based on

TIME  
CAPSULE

$\Downarrow$   
we will discuss  
in Chpt. 6

hyperconjugation  
that introduces  
strain unless the H  
atoms are in the  
staggered geometry

The ethane molecule rotates freely at room temperature, but because of torsional strain, it spends most of its time in the staggered conformation.



New type of strain  $\rightarrow$  important for  
alkanes of 4 or more  
carbon atoms

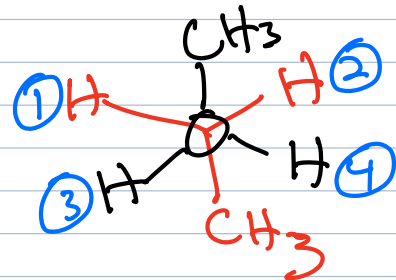
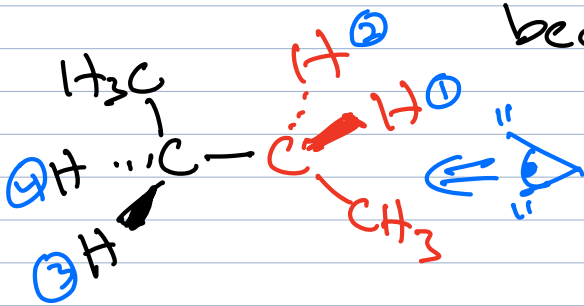
Steric strain  $\rightarrow$  strain caused when  
when atoms "crunch"  
into each other

Butane  $\rightarrow$  4 carbon atoms

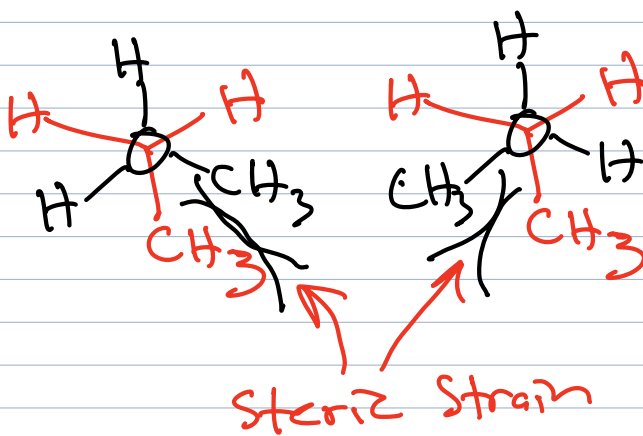
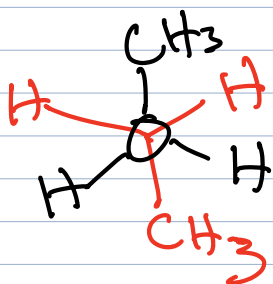
3 different staggered conformations

$\Rightarrow$  These differ in energy

because of steric strain



3 different staggered conformations



Anti

(methyl groups are as far apart as possible)

No steric strain

Lower energy

Gauche

(methyl groups are adjacent)

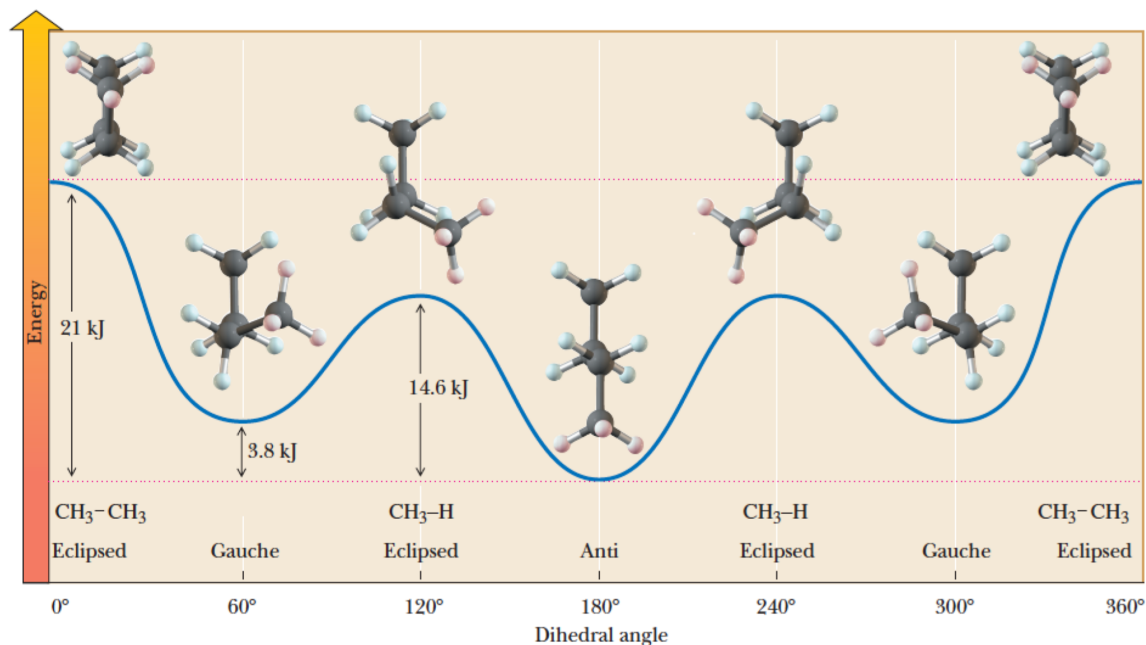
Steric strain

because "poor"

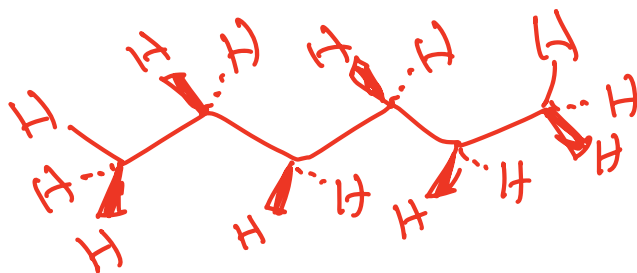
methyl groups

crunch into each other

Higher Energy



Important consequence → for longer alkanes → alkane chains exist primarily in a "zig zag" conformation so that all the bonds are staggered anti most of the time



Dynamizes  $\rightarrow$  heat in molecules causes amplitude of bond vibrations to increase

Very disorganized bond rotation  $\rightarrow$  Vibrations and rotations are coupled in molecules  $\rightarrow$  vibrations that lead to bond rotations

Angle strain  $\rightarrow$  present any time an angle around an  $sp^3$  C is different than  $109.5^\circ$

$\rightarrow$  Happens in ring structures

# Cycloalkanes

Cyclopropane

↓  
Highly Strained



High angle strain  
and  
torsional strain

Cyclobutane

↓  
Highly Strained



Not flat

Angle and  
torsional  
strain

"Puckers"  
to relieve  
some strain

Cyclopentane

"Puckers" to create  
an "envelope"  
conformation



Very little strain

Little angle strain  
but some torsional  
strain

Cyclohexane  $\rightarrow$  most stable cyclohexane

$\rightarrow$  Adopts a chair conformation



Minimal  
angle  
strain



No torsional  
strain

You will need to know how to draw  
a **great** chair cyclohexane

$\Rightarrow$  "Keep it parallel"

