cyclopropane - flat.

\[ \text{H}_2\text{C} - \text{H} - \text{H} \]

all eclipsed

very strained molecule

What is "ring strain"?

Two components:

1. angle strain - caused by distortion of bond angles away from tetrahedral.
   (cyclopropane: \(60^\circ\) vs \(109.5^\circ\))

2. steric strain - caused by eclipsing hydrogens / substituents
How can we quantify this? We can measure the heat of combustion for straight-chain alkanes. For every CH₂ added to the chain, ΔH° increases by about 157 kcal/mol.

Propane: ΔH = -530.6
Butane: -687.4
Pentane: -845.2

Since cyclic alkanes have formula (CH₂)n, we should be able to predict ΔH for combustion:

<table>
<thead>
<tr>
<th>Ring</th>
<th>Predicted</th>
<th>Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cyclopropane</td>
<td>-492.2 kcal/mol</td>
<td>-499.8 kcal/mol</td>
</tr>
<tr>
<td>Cyclobutane</td>
<td>-629.6</td>
<td>-655.9</td>
</tr>
<tr>
<td>Cyclohexane</td>
<td>-944.4</td>
<td>-944.5</td>
</tr>
</tbody>
</table>

Δ = 27.6 kcal/mol
Look @ lots of examples:
small rings (3,4) – highly strained
common rings (5,6,7) – little strain
medium rings (8-12) – strained
large rings (>12) – little strain

cyclopropane

60° bond angles – very distorted.

c-c bonds in

cyclopropane are relatively weak
(not formed by max. orbital overlap)

DTθ° (bond strength)
= 65 kcal/mol

Compare: 90 kcal/mol in ethane
cyclobutane - not planar - puckered

\[ \triangle \]

\[ \text{bent } 26^\circ \text{ out of planarity.} \]

- decreases bond angles (thereby increases that component of ring strain)

- lets it's get away from being eclipsed (decreases the steric/torsional strain)

\[ \Delta \text{ or } \square \]

\[ \text{H}_2 \rightarrow \text{Pd} \]

\[ \rightarrow \text{ } \]

\[ \rightarrow \text{ } \]
Cyclopentane - might be expected to be planar (108° bond angles) - but the steric/torsional strain would be very high.

Instead, it is also puckered. This increases the angle strain somewhat, but greatly decreases the steric strain.

Overall - very little strain.

cyclohexane

Most stable conformation called "chair" - tetrahedral bond angles zero eclipsing interactions.

Strain - Free
Conformational change:

chair $\rightarrow$ boat

bowspit

boat

stereic problems.

chair

boat

transannular strain)

all staggered

all eclipsed
"ring flip" - convert one chair into the other

This interconverts axial + equat