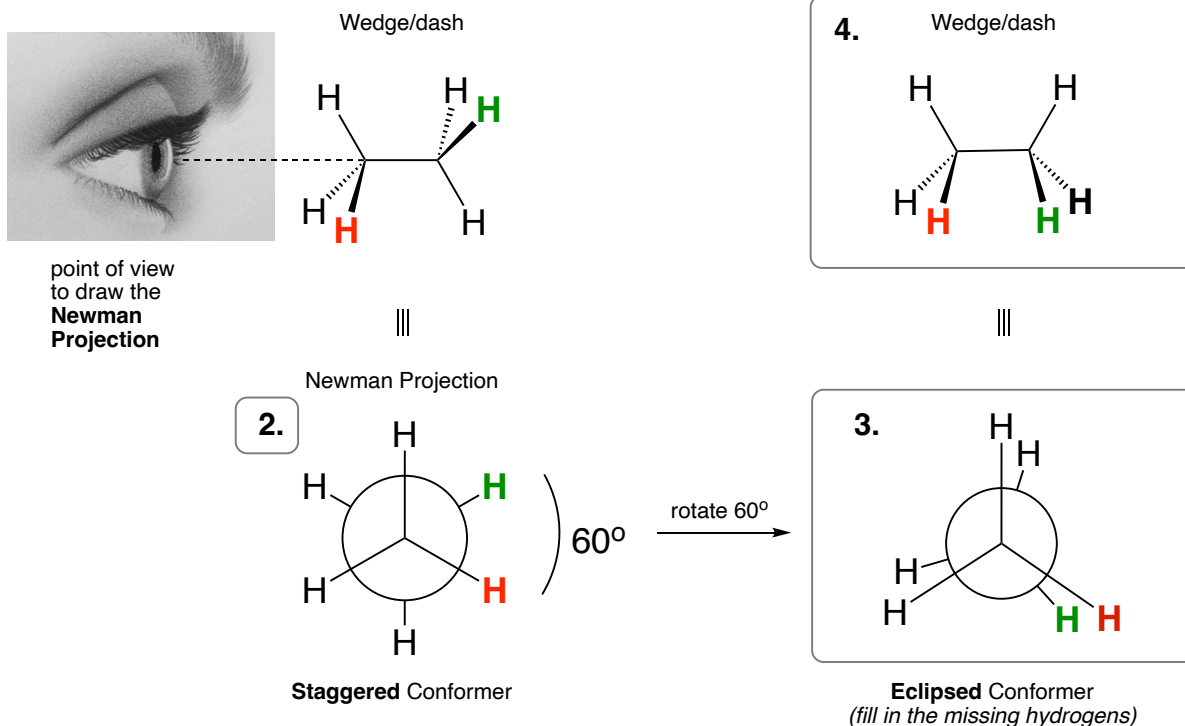


Consider the **staggered** Newman Projection of ethane. Using your model kit, build ethane.

1. What does the big circle represent in the Newman Projection?

The carbon in the back

2. Circle the three hydrogens in the back of the **staggered** conformer (see diagram below).



3. Rotate the **bold hydrogen** in the back carbon by 60° and *finish drawing* the Newman projection of the **Eclipsed** Conformer.

4. In the blank box provided above, draw the wedge/dash structure of the missing conformational isomer.

5. Explain the names **staggered** and **eclipsed** in Ethane: _____

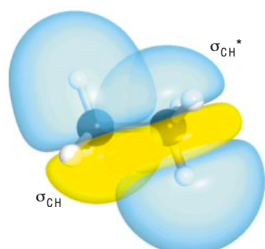
Staggered: The relative position between the two H-atoms where the dihedral angle between them is 60°.

Eclipsed: The relative position between the two H-atoms where the dihedral angle between them is 0°

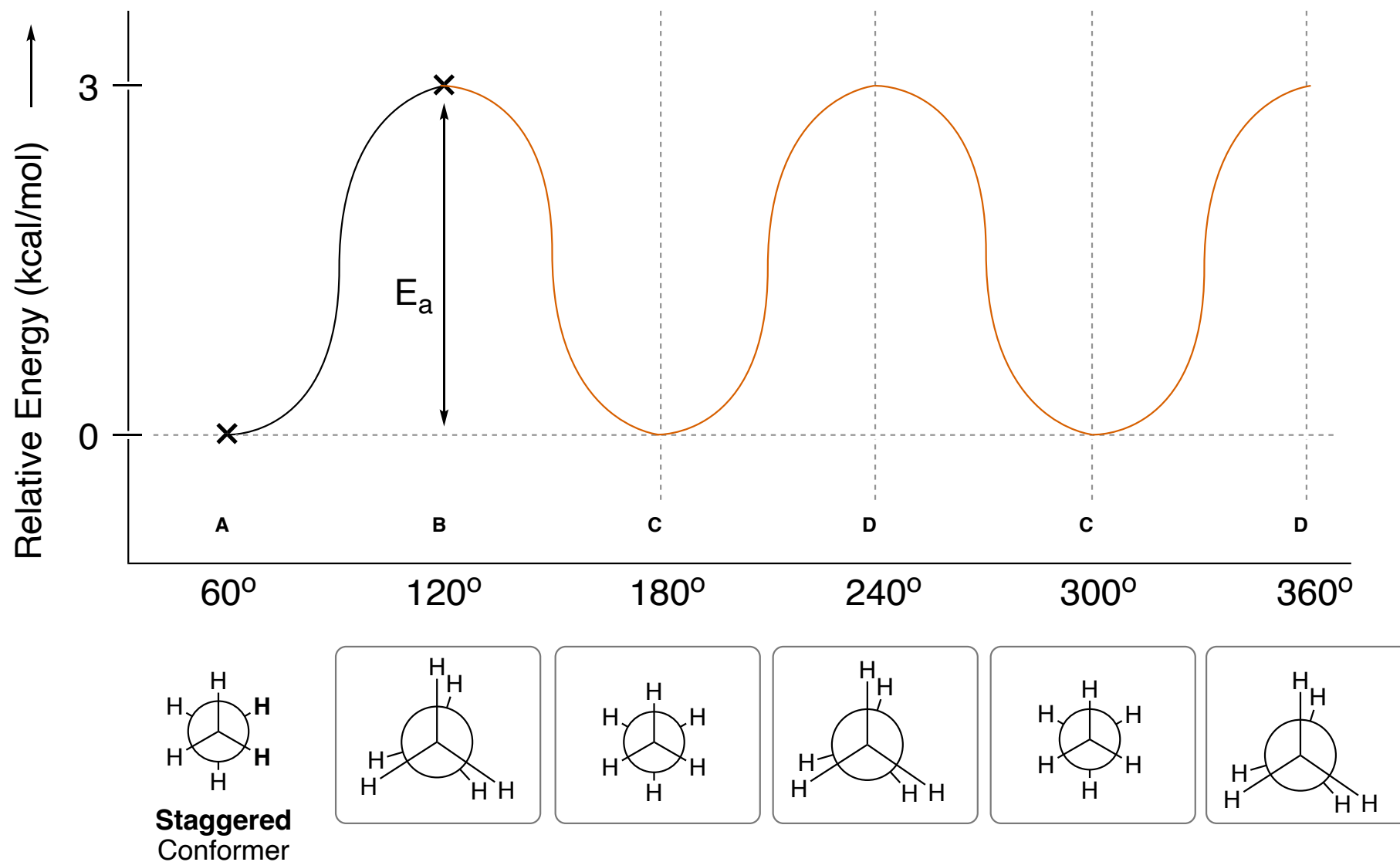
6. The **staggered** Newman projection is more stable than the **eclipsed** rotational isomer. Propose an explanation (3 sentences or less): _____

Torsional strain: resistance to twist/rotate in relationship to adjacent bonds/groups.

Arises from *hyperconjugation*. The degree of delocalization of electrons resulting from the overlap of a filled σ orbital with a neighboring empty orbital. In this case, it is the σ^* (antibonding) orbital of ethane.



7. In a free energy diagram for the rotation about the C-C bond in ethane, the **eclipsed** conformer is higher in energy by 3 kcal/mol than the **staggered** conformer. Complete the free energy diagram for the rotation about the C-C σ -bond (hint: rotate the carbon in the back). Put an "X" where you expect the free energy value for the rest of the conformers and connect the X's with a line, as initially shown.

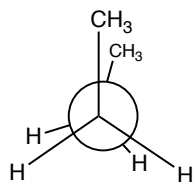
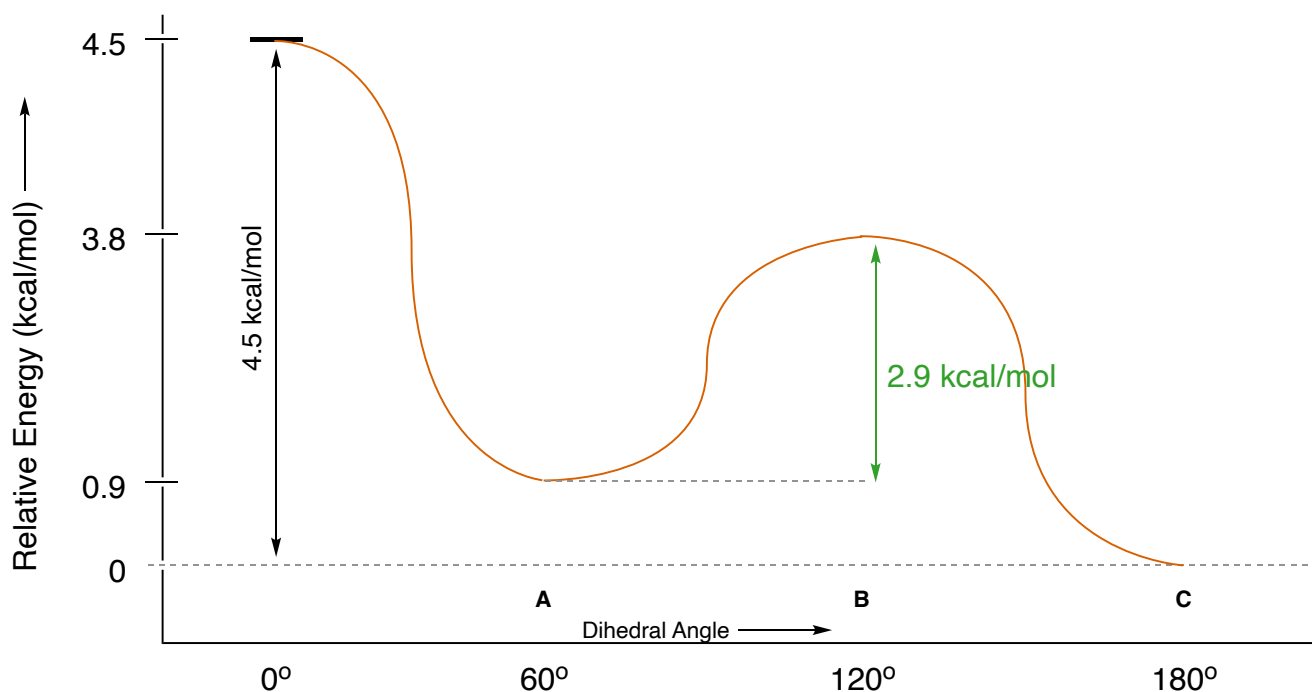


Note: E_a is the **activation energy**. *i.e.* the energy required to overcome the barrier to rotate from 60 to 180 degrees.

Worksheet adapted from: Dr. Andrei Straumanis and Prof. Chris Douglas

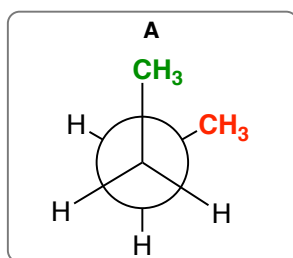
Using your model kit, build **Butane**.

1. Considering the energy interactions written on the board (at various dihedral angles of $R_1-C_A-C_B-R_2$), complete the free energy diagram for the rotation of the σ -bond between the second and third carbons of butane. (the numbers are also written on the back of this sheet).

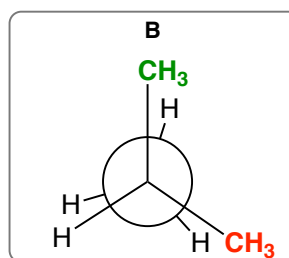


Name of Conformer

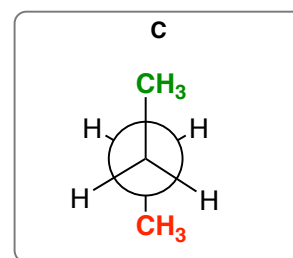
eclipsed



gauche



H / CH₃ eclipsed



anti

Put an "X" in the box for the lowest energy conformer

☐
☐
☐
☒

2. What is the activation energy for the rotation:

from 60° to 180°? 2.9 Kcal/mol (3.8 – 0.9)

from 180° to 60°? 3.8 Kcal/mol

from 60° to -60°? 3.6 Kcal/mol (4.5 – 0.9)

3. Explain why is the gauche conformer higher in energy than the anti conformer (3 sentences or less):

This energy difference occurs because the hydrogen atoms of the methyl groups are near one another in the gauche conformation, resulting in what is called *steric strain*.

Steric strain is the repulsive interaction that occurs when atoms are forced closer together than their atomic radii allow. It's the result of trying to force two atoms to occupy the same space.