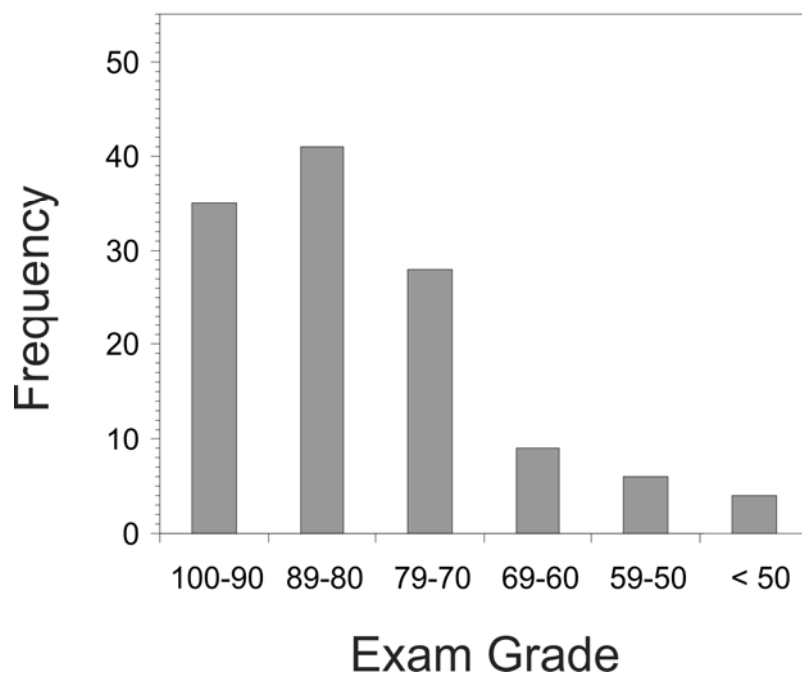


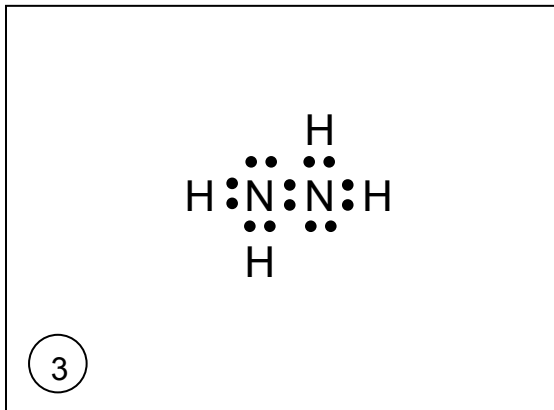
**Exam 1
Answer Key**

Exam 1 Mean: 81
Exam 1 Median: 83
Exam 1 St. Dev.: 14

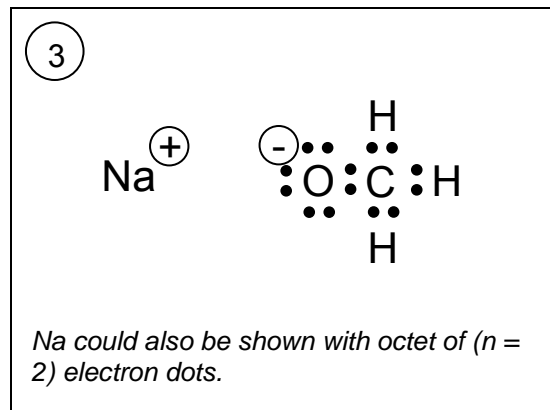


1. (9 pts) **Draw Lewis dot structures** for each of the molecules below. Draw all valence electrons as dots. If there are formal charges, draw them on the appropriate atoms.

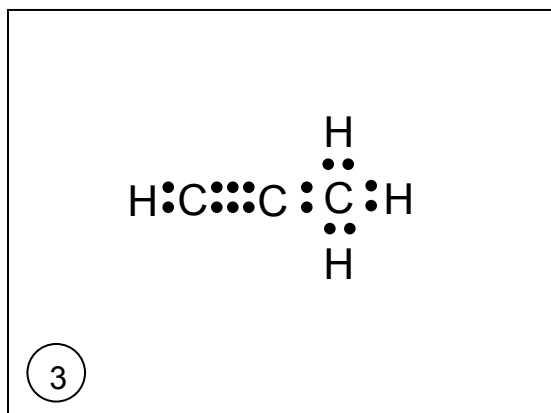
(a) hydrazine, H_2NNH_2



(b) sodium methoxide, CH_3ONa



(c) propyne, HCCCH_3



Rubric:

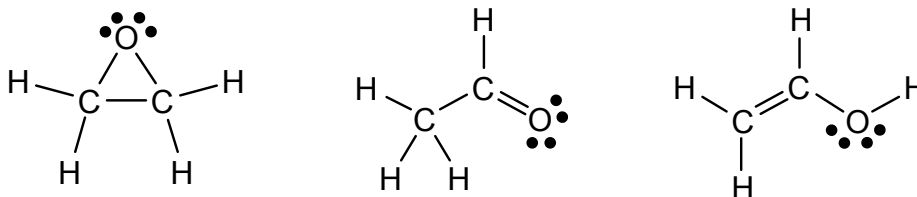
3 points each box.

-1 point for each missing or incorrectly assigned charge or electron pair.

1 point partial for drawing bonds as lines instead of dots.

2. (6 pts) **Draw Lewis dash-bond structures** for two constitutional isomers that have molecular formula C_2H_4O , and that have **no formal charges** on any atom. Draw all atoms and lone pairs of electrons.

There were actually only three possible answers to this question:



Rubric:

3 points each correct structure.

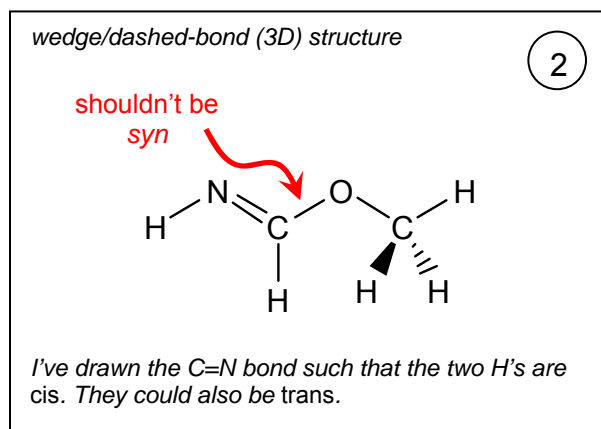
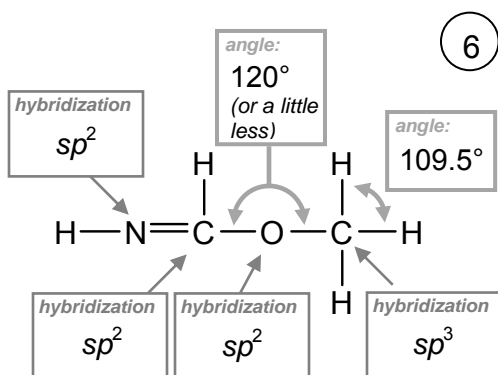
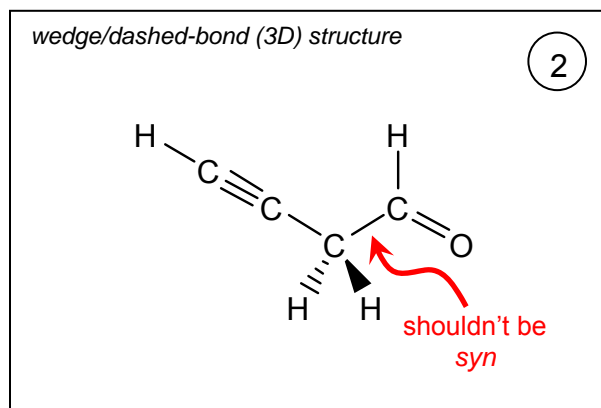
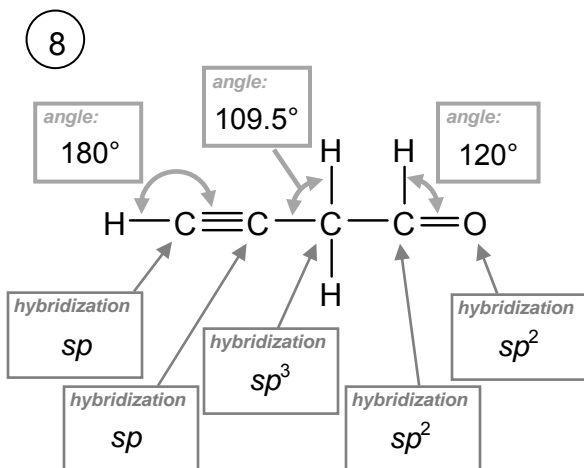
-1 point for each missing electron pair, dot, bond, or atom.

Structures that have formal charges, or that should have formal charges, receive no credit.

1 point partial for drawing a structure with incorrect molecular formula (say, $C_2H_4O_2$), but otherwise completely correct (and with no formal charges).

If you drew same structure twice (e.g., as resonance structures), or you drew stereoisomers instead of constitutional isomers, we gave you credit for one but not the other.

3. (18 pts) For each of the Lewis structures drawn below, in the boxes provided:
- Draw Lewis wedge/dashed-bond structures that illustrate the three-dimensional structure of the molecule. Draw all atoms, but feel free to omit lone pairs.
 - In the boxes provided, write the hybridization state for any atom heavier than hydrogen.
 - In the boxes provided, give any bond angle indicated by curved arrows in the original Lewis structure.



The indicated bonds have their largest, most sterically demanding groups either *anti* or at a dihedral angle of $> 90^\circ$ with respect to one another.

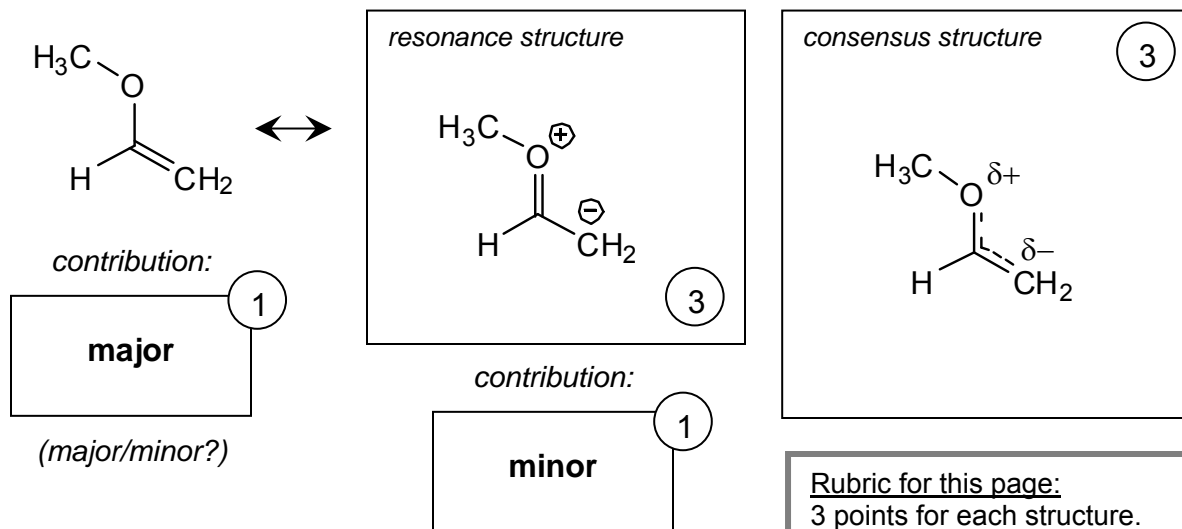
Rubric:

1 point for each bond angle and hybridization (14 total).

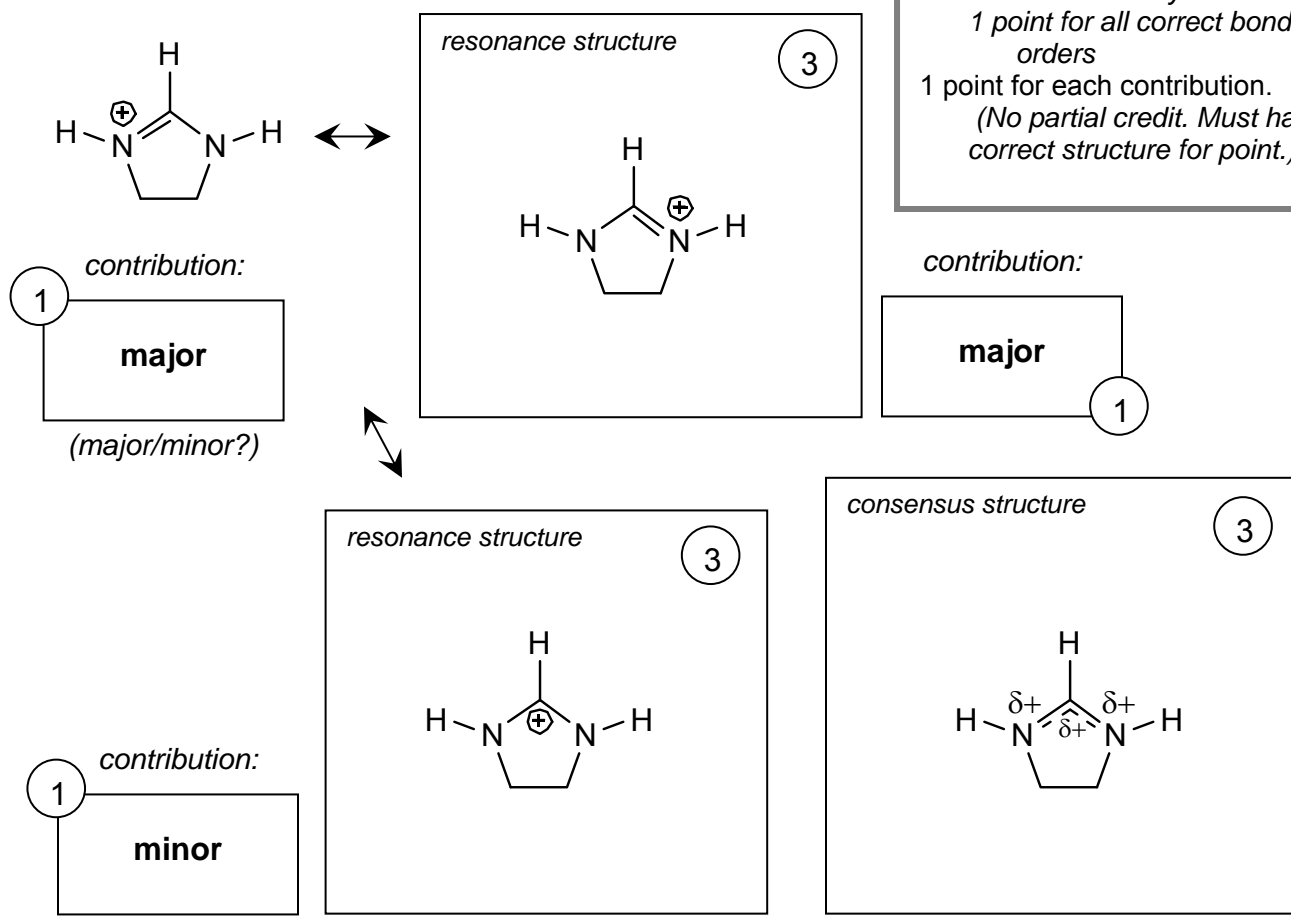
2 points for each 3-D structure (4 total).

-1 for each incorrect center or bond rotation (up to 2).

4. (20 pts) For each of the molecules on the left, draw as many Lewis dash-bond resonance structures as there are boxes. (Feel free to omit lone pairs and C-H's, or draw them—your choice.) Then, below each resonance structure, describe whether each would be a major or minor contributor. Finally, draw a consensus structure that illustrates partial charges and multiple bonds.

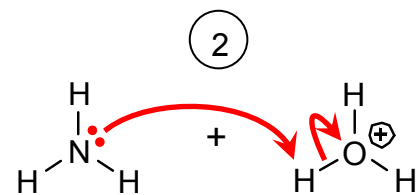


Rubric for this page:
 3 points for each structure.
 2 points for all charges correct and internally consistent
 1 point for all correct bond orders
 1 point for each contribution.
 (No partial credit. Must have correct structure for point.)

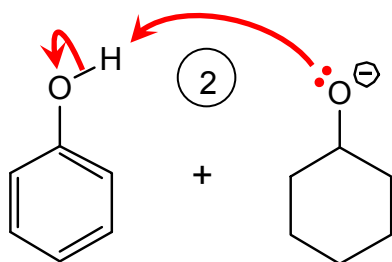
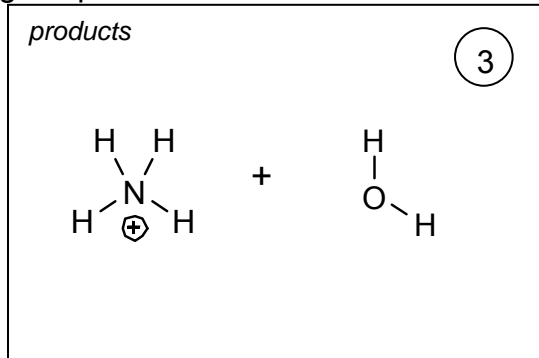
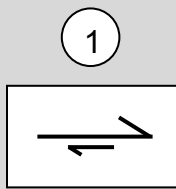


5. (18 pts) For each of the sets of molecules below:
- Using “electron pushing” (with double-barbed arrows), show how the molecules on the left would react in an acid-base reaction to transfer a proton from one to the other.
 - In the box on the right, draw the conjugate acid and base products of each reaction.
 - In the middle, draw an equilibrium arrow that shows whether you feel the acid-base equilibrium would lie on the left or the right.

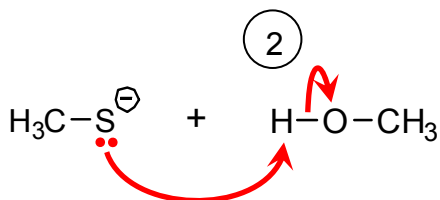
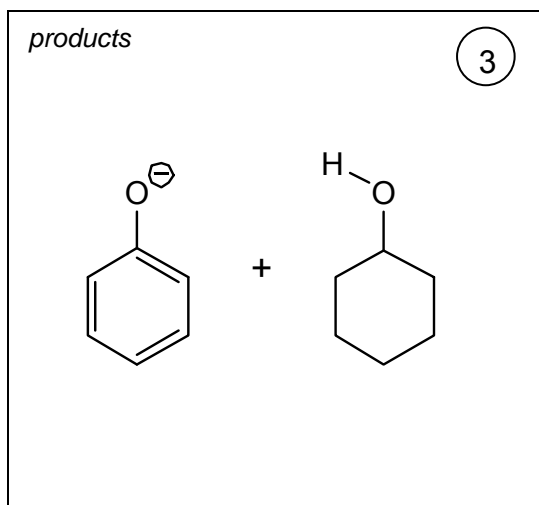
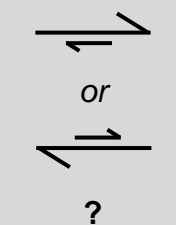
For each equilibrium, ask yourself: which charged species is more stable?



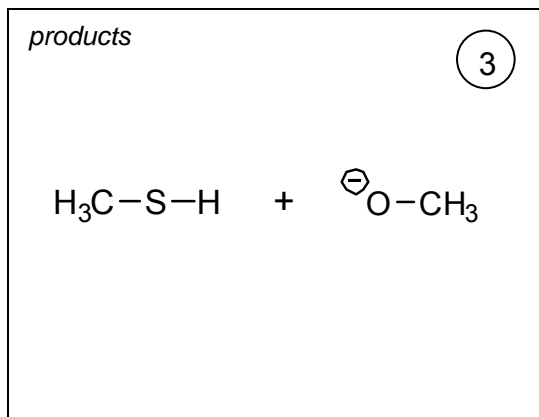
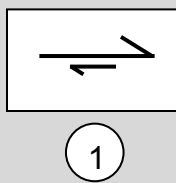
N is less electronegative than O, so it's happier with the positive charge. Equilibrium pushed to the right.



Anion product stabilized by resonance, but anion starting material is not. Equilibrium pushed to the right.



S is larger than O, so the negative charge is more distributed and more stable. Equilibrium pushed to the left.



Rubric: For each acid-base reaction,

2 points for electron pushing (one point each curved arrow).

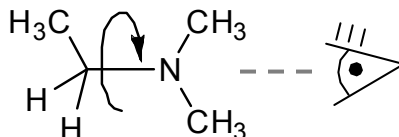
1 point total for the set of 2 arrows if you drew the lines in the correct place, but arrow heads were incorrect.

1 point for equilibrium arrow direction.

3 points for each set of products. Structures must be correct.

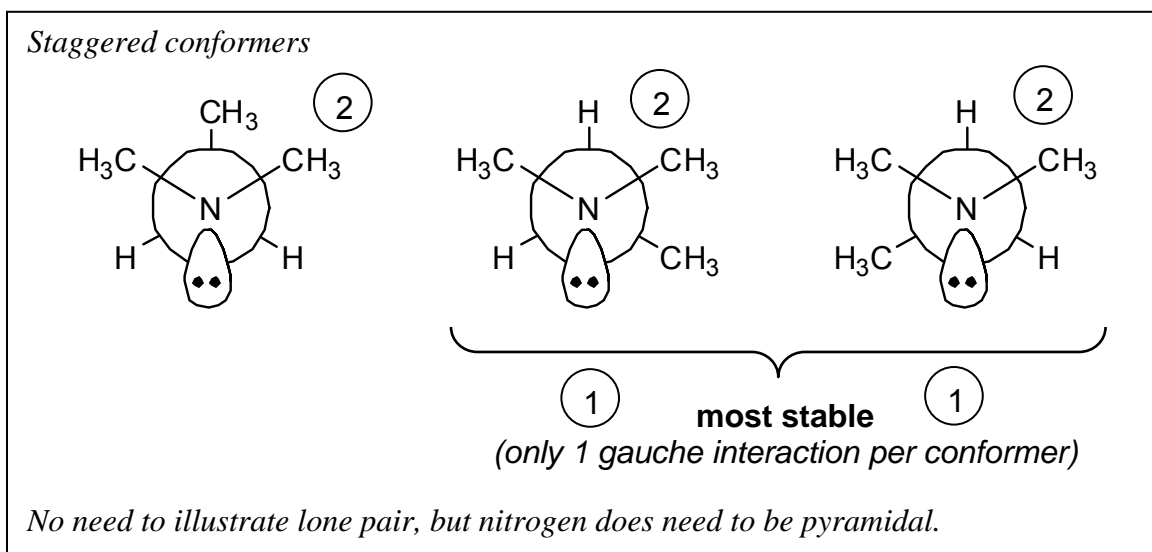
2 points partial for one of two products correct.

6. (16 pts) For the molecule (dimethylamino)ethane (below):



(a) Draw Newman projections for the six conformers—three staggered and three eclipsed—accessed by rotation of the central C-N bond. Use the perspective I've indicated (with the nitrogen atom closest to the viewer).

(b) Label which conformer you would expect to be most stable, and which you would expect to be least stable. If there are multiple conformations that are equally most or least stable, label them all.



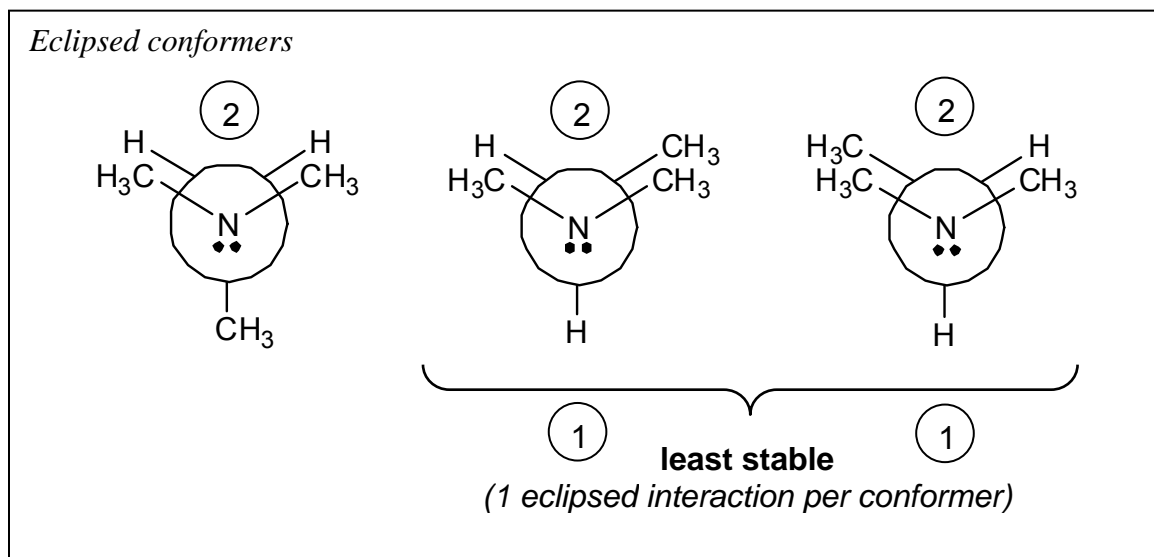
Rubric for (a/b):

2 points for each conformer.

Two of the staggered conformers and two of the eclipsed conformers are mirror images of each other. They have identical characteristics, but they are technically not the same. You need to draw each one. If, instead of drawing the two, you draw the same one twice, you get 2 points for one of them and not the other.

1 point for each conformer drawn with a trigonal planar nitrogen (if all else is correct).

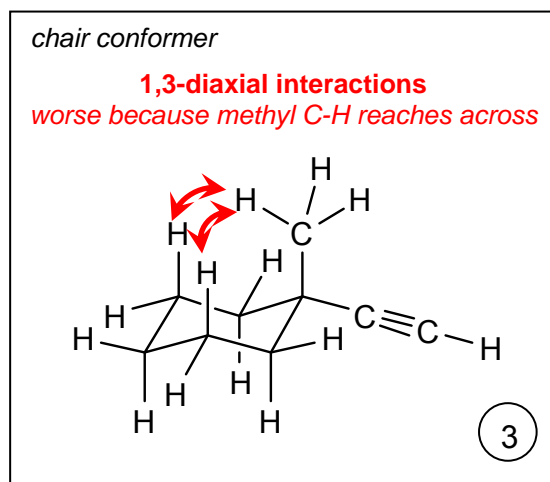
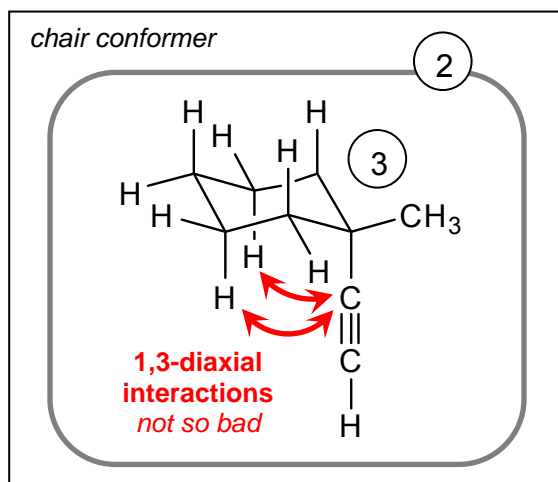
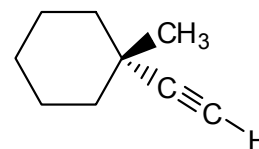
- 1 point for omitting nitrogen atom in your drawings, or for making the central atom a carbon and drawing an "N" where you should have drawn a lone pair.
 1 point for each assignment of most/least stable.



Same rubric as previous page.

7. (13 pts)

- (a) The substituted cyclohexane on the right has two chair conformers. Draw the two conformers in the boxes below. Draw all atoms except the six carbons of the cyclohexane ring—so, draw all hydrogens and both the $-\text{CH}_3$ and $-\text{C}\equiv\text{CH}$ substituents.



(b) Circle the conformer above that you think will be more stable.

The basic question being asked here is, which group would be less stable in the axial position—the methyl ($-\text{CH}_3$) or the alkyne ($-\text{C}\equiv\text{CH}$)? We used the methyl group as a prototypical cyclohexane substituent in class, and we said there were two reasons why it was bad for $-\text{CH}_3$ to be axial instead of equatorial: (i) the C-C bond of an axial methyl group experiences *gauche* interactions with bonds in the cyclohexane ring; and (ii) the electrons in the C-H bonds of the methyl group reach across the ring and repel the electrons in the axial C-H bonds two carbons away. (We called these “1,3-diaxial interactions” in class.) In this problem, both the methyl group and the alkyne group have a C-C bond that would experience *gauche* interactions with bonds in the cyclohexane ring if they were axial, so (i) is not a reason to distinguish which of the two groups would be less stable in the axial position. Considering (ii), on the other hand, the alkyne does not have C-H bonds coming out the side that would experience 1,3-diaxial interactions; an axial $-\text{C}\equiv\text{CH}$ would stick straight up/down, away from the C-H's on the other side of the ring.

Rubric for (a/b):

3 points for each chair conformer.

1 point for drawing a chair.

1 point for all H's drawn in correct orientations (one axial, one equatorial per C).

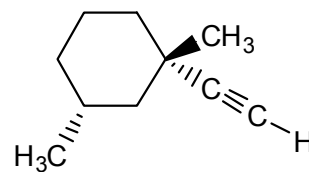
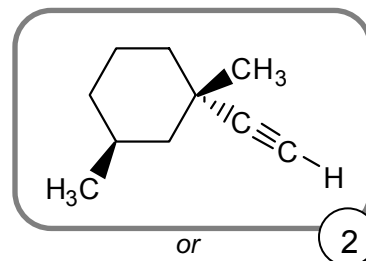
1 point for drawing one axial substituent, and then one equatorial substituent on the same carbon.

If you draw same ax/eq pattern twice (e.g., two structures with $-\text{CH}_3$ axial in both), you only get the point for one of them.

2 points for circling structure with $-\text{CH}_3$ equatorial.

Can only get these points if $-\text{CH}_3$ is axial in the other structure. Doesn't matter what the rest of the structure looks like.

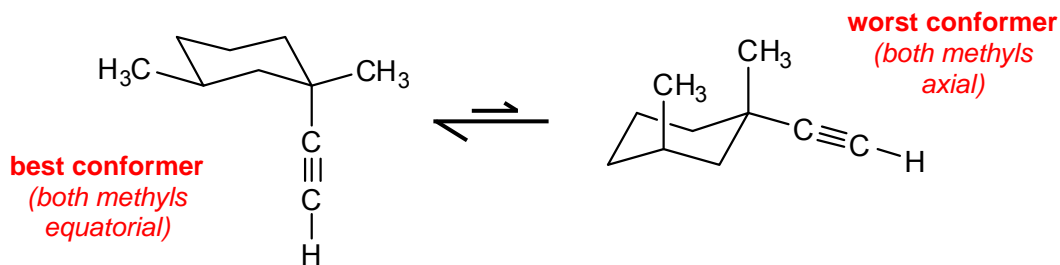
(c) The two molecules on the right are like the molecule above, except they each have an additional methyl group. Which would be more stable? Circle one of the two molecules.



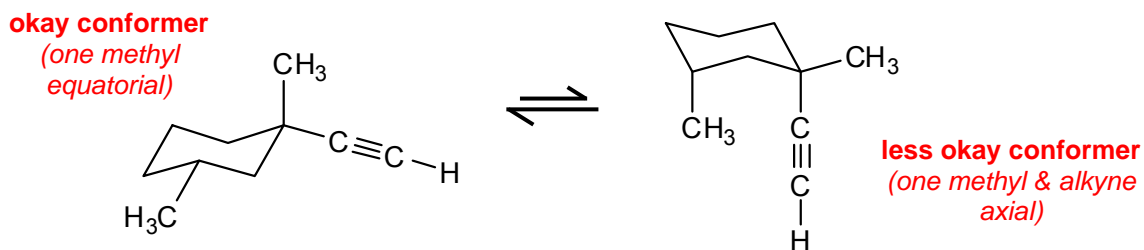
(circle one)

So if we conclude that it's worse to have an axial $-\text{CH}_3$ group than an axial $-\text{C}\equiv\text{CH}$ group (from the previous part), then the most stable dimethyl-substituted molecule is going to be the one that can have both $-\text{CH}_3$ groups equatorial. So, to answer this question, you needed to consider chair conformers for both molecules.

Top molecule:

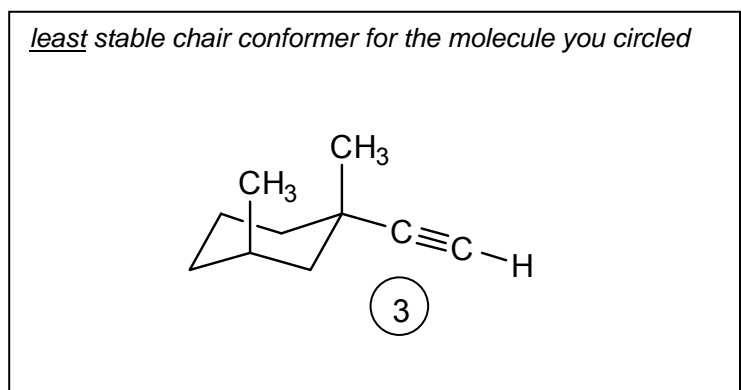


Bottom molecule:



The top molecule is most stable because it can spend all its time in the most stable conformer. The bottom molecule doesn't have a good conformer to choose from—both conformers put one methyl group axial—so it is less stable overall.

- (d) Interestingly, the *more* stable of the two molecules at right has the *least* stable chair conformer. For the molecule that you circled, draw the chair conformer that you think would be **least stable**. Feel free to omit the ring hydrogens—just draw the ring and substituents.



Rubric for (c/d):

2 points for circling *cis*-dimethyl structure.

This structure is most stable because it can put both methyl groups equatorial.

3 points for conformer with both methyl groups axial.

1 point for each substituent in the correct place.

If you circled the wrong molecule above, you get partial credit (2 points) for this part if you drew its diaxial conformer:

