CHEMISTRY 3A SPRING 2012

EXAM I

FEBRUARY 16, 2012

NAME Answer Key

SECTION AND/OR TA IF YOU ARE IN THE LABORATORY COURSE: _____

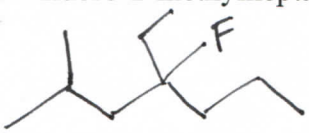
STUDENT ID: _____

- **You will have 2 hours in which to work.**
- **BE NEAT! Non-legible structure drawings will not be graded.**
- **All pages of the exam must be turned in.**
- **No calculators**
- **Molecular models may be used**

Question	Points (Maximum)	Points (Obtained)
1	18	
2	31	
3	41	
4	42	
5	23	
6	25	
7	20	
Total	*200*	

1. (18 points) Draw line drawings of the following molecules. Use wedges and dashes to illustrate stereochemistry.

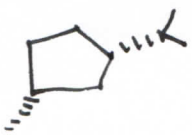
a) 4-ethyl-4-fluoro-2-methylheptane



stereochemistry does not need to be indicated, but OK if just one enantiomer drawn

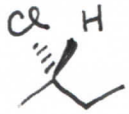
b) *cis*-1-isopropyl-3-methylcyclopentane

or



either or both OK

c) (S)-2-chlorobutane



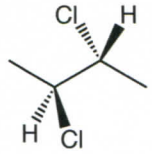
2. (31 points) For the following pairs of molecules:

i) Identify whether the pairs of the following molecules are enantiomers, diastereomers, constitutional isomers, or the same molecule.

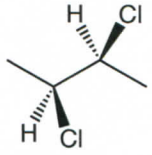
ii) Label each molecule as chiral or achiral.

iii) Label any molecules that are meso.

a.



and



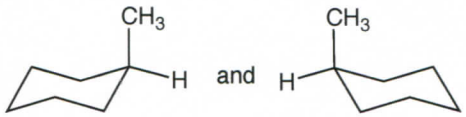
diastereomers

achiral

chiral

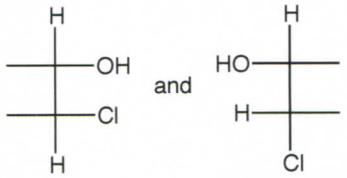
meso

b.



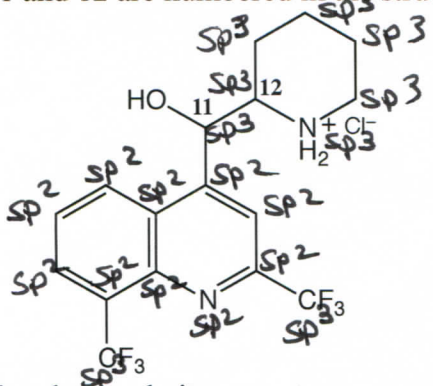
achiral achiral same molecule

c.



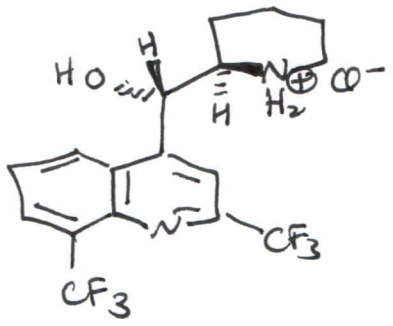
Chiral Chiral diastereomers

3. (41 points) The antimalarial drug erythro-mefloquine (Lariam) is shown below. This drug is sold as a racemic mixture of (+) and (–) compounds. It is believed that (+)-erythro-mefloquine is responsible for anti-malaria properties, while (–)-erythro-mefloquine is responsible for the side effect of psychosis. Positions 11 and 12 are numbered in the structure below.

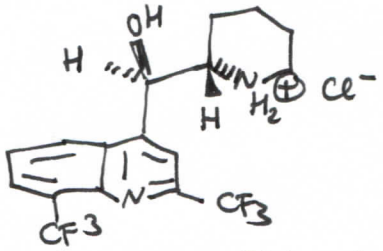


a) Label all carbon and nitrogen atoms as sp, sp^2, or sp^3 hybridized in the structure above.

b) This year, scientists determined that (+)-erythro-mefloquine is the (11S,12R) stereoisomer. Note that positions 11 and 12 are indicated in the above structure. Draw this isomer, clearly indicating stereochemistry.



c) Draw the structure of the enantiomer of (+)-erythro-mefloquine.



d) Draw a diastereomer of (+)-erythro-mefloquine.

e)A scientist at Merck Pharmaceuticals decides to try to synthesize only (+)-erythro-mefloquine. The sample of erythro-mefloquine that they make has a specific rotation of +60. If the specific rotation of pure (+)-erythro-mefloquine is +180, what is the enantiomeric excess (%ee) of the sample? What are the percentages of (+)-erythro-mefloquine and (-)-erythro-mefloquine in the sample? Show your work.

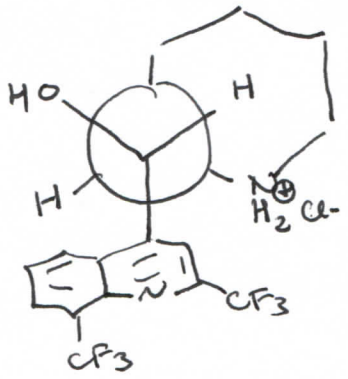
$$\frac{60}{180} = 33.33\%$$

33.33% (+)

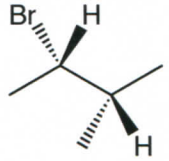
66.67% racemic → 33.33% (+) & 33.33% (-)

∴ 66.67% (+) & 33.33% (-)

f) Draw a Newman projection of the most stable structure looking down the C11-C12 bond of (+)-erythro-mefloquine. Is this the conformation that you drew as your answer to part b of this question?



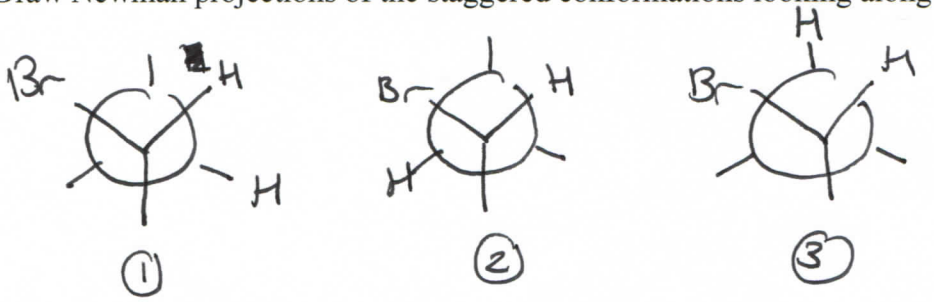
4. (42 points) A friend of yours goes to the laboratory and prepares to do a reaction with the following molecule.



a) Name the above compound, including stereochemistry.

(S)- 2-bromo -3-methylbutane

b) Draw Newman projections of the staggered conformations looking along the C2-C3 bond.

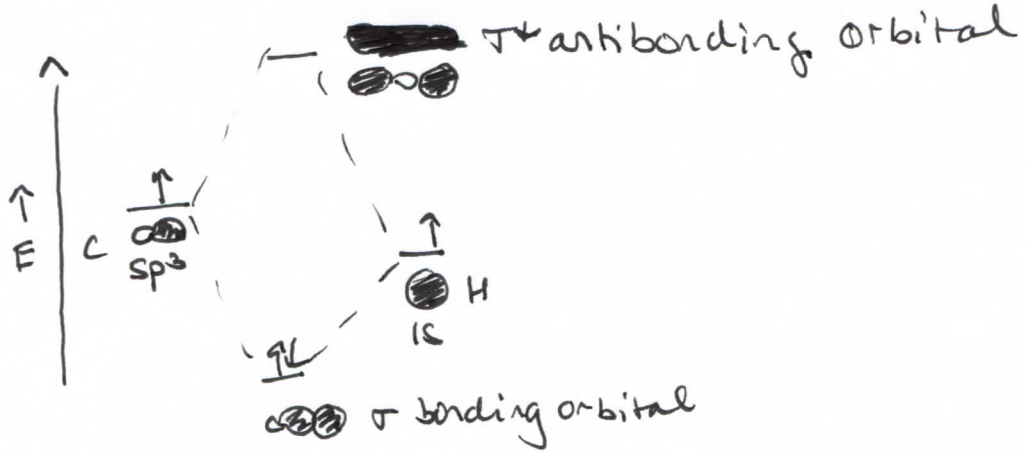


c) Your friend plans to do a reaction with this molecule that requires the bromine on C2 to be anti relative to the hydrogen on C3. Which Newman projection from your answer in part b represents this conformation? Structure ①

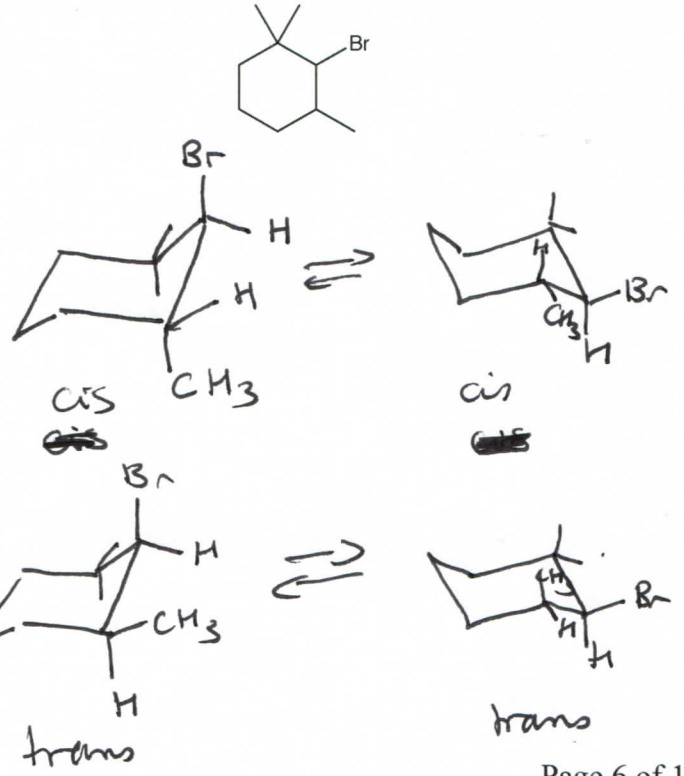
d) What is the most stable conformation of this molecule? Bromine is smaller than methyl, but larger than hydrogen.

Structure 2.

e) Draw and label a molecular orbital diagram for the bond formed between C3 and hydrogen. Include pictures of the orbitals you use to make the bond and pictures of the molecular orbitals formed.

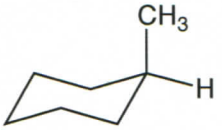


f) Your friend decides to do similar reaction with the molecule below. Should your friend use the stereoisomer in which the bromine and hydrogen are *trans* or the one in which they are *cis* to each other? Draw the molecules in their chair conformations to help you decide. Explain your answer.

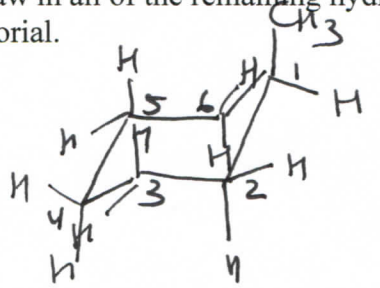


Friend should use molecule in which Br and H are trans because this is the only molecule in which an anti orientation can be achieved in one conformation

5. (23 points) Consider methylcyclohexane shown below.

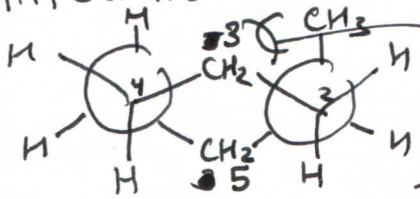


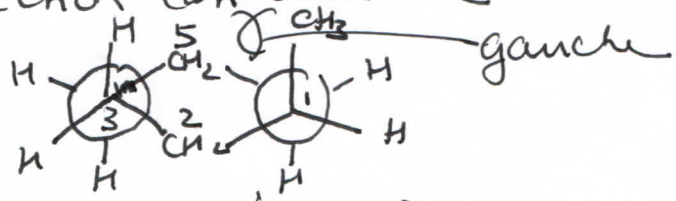
a) Draw in all of the remaining hydrogens on this molecule and label all groups as either axial or equatorial.



b) Explain why the CH_3 group in methylcyclohexane is less stable in an axial position than in an equatorial position. What is the name of this type of destabilization?

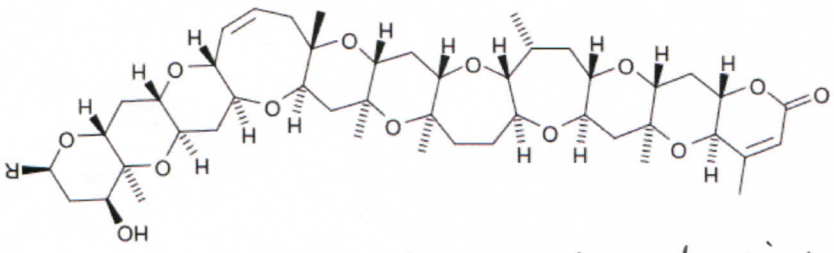
CH_3 is less stable in axial position because it is destabilized by steric interactions with the CH_2 groups at the 3 & 5 positions. These are called 1,3-diaxial interactions and are gauche interactions. A Newman projection can illustrate:





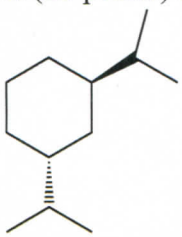
There are two gauche interactions

c) Brevitoxin B, shown below, is a neurotoxin that causes Neurotoxic shellfish poisoning, or Red Tide. Can any of the 6-membered rings in this molecule undergo a ring flip? Explain your answer?

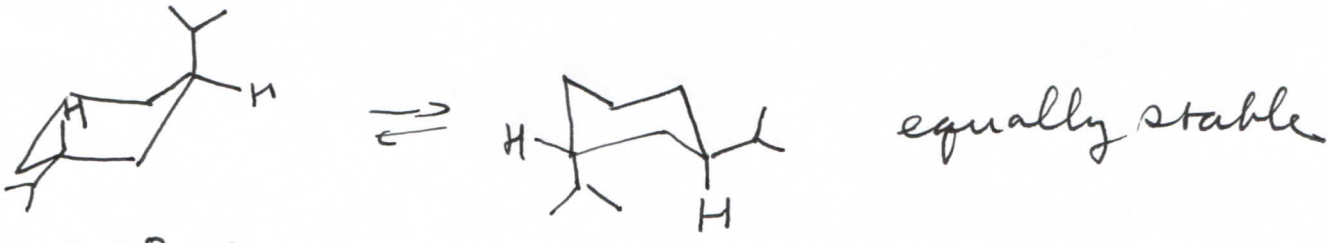


None of the 6-membered rings can undergo a ring flip because they are fused together trans. Trans-fused rings can not undergo ring flip because the six-membered ring can not span across the diaxial geometry.

6. (25 points) For each of the following molecule:



a. Draw both chair conformations.
b. Identify which chair conformation is more stable or whether they are equally stable.
c. Calculate the free energy difference between the two structures. ΔG° for the conversion of the cyclohexane conformer with the isopropyl group equatorial to the conformer with the isopropyl group axial is 2.20 kcal/mol.
d. What are the relative amounts of each conformation in solution? Write an equation to show how you calculated your answer.



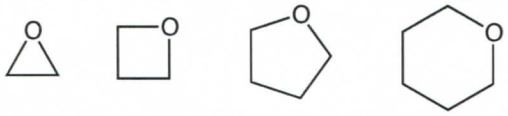
equally stable

$\Delta G^\circ = 0$

$\Delta G^\circ = -RT \ln K$

$0 = -RT \ln K$ $\quad K = 1$ Equal amounts of each conformation

7. (20 points) Consider the following molecules:



a) How would you measure the relative stabilities of these molecules?

The heat of combustion could be used to measure the relative stabilities of these molecules.

b) How would you measure ring strain?
Divide ΔH_c° by # of CH_2 groups. Subtract ΔH_c° of CH_2 group in strained ring from that of CH_2 group in unstrained ring to get the strain/CH_2. Then multiply ~~by~~ # this strain/CH_2 by # of atoms in ring to get total strain.

c) Which of these molecules would you expect to be more reactive in a reaction that would break the C-O bond and open the ring to form a more stable product? Explain your answer. You can assume that oxygen's preferred hybridization is sp^3 in these molecules, and the structures of the rings are similar to those containing only carbon.

The most reactive will be 

 has the largest ring strain because the angles of the ring are 60°, but the preferred angles of an sp^3 C are 109.5°. There are also destabilizing eclipsing interactions. This ring strain makes the bonds that form the ring weaker. Therefore, in a reaction to form a more stable product, it will require less energy to break the C-O bond in  than in a less strained ring. Therefore,  will be more reactive