Last Name	First Name	MI
Student ID Number:		***Total Score***
Circle the name of your TA: **MIKE** **ROB**		
Discussion Section – Day: **Time:**		**/ 100**

Chem 30A Winter 2005

MIDTERM #1

(50 Min)

Weds February 2nd

INTERPRETATION OF THE QUESTIONS IS PART OF THE EXAM – DO NOT ASK FOR THE QUESTIONS TO BE EXPLAINED TO YOU

ONLY ANSWERS WRITTEN IN THE BOXES PROVIDED WILL BE GRADED

******DO NOT OPEN THIS EXAM UNTIL INSTRUCTED TO DO SO******

Q1	**/ 24**	**Q4**	**/ 22**
Q2	**/ 18**	**Q5 *BONUS***	**/ 5**
Q3	**/ 36**	**Q6 *BONUS***	**/ 10**
		Total	**/ 100**

"A common mistake that people make when trying to design something completely foolproof is to underestimate the ingenuity of complete fools"
– Douglas Adams

Q1. (a) Using **LINE FORMULAE** draw the four different **CONSTITUTIONAL** isomers with the molecular formula C_4H_9Cl (2 pt each) (b) Name each isomer using **SYSTEMATIC** naming rules, in the knowledge that chloro groups are higher in priority than methyl groups (i.e., they get the smaller positional number if a choice has to be made) (2 pt each)

A

Name

B

Name

C

Name

D

Name

(c) Which of the constitutional isomers of C_4H_9Cl (**A**–**D**) has the highest boiling point (79 °C)? (2 pt)

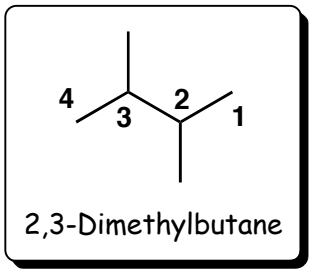
(d) Which of the constitutional isomers of C_4H_9Cl (**A**–**D**) has the lowest boiling point (51 °C)? (2 pt)

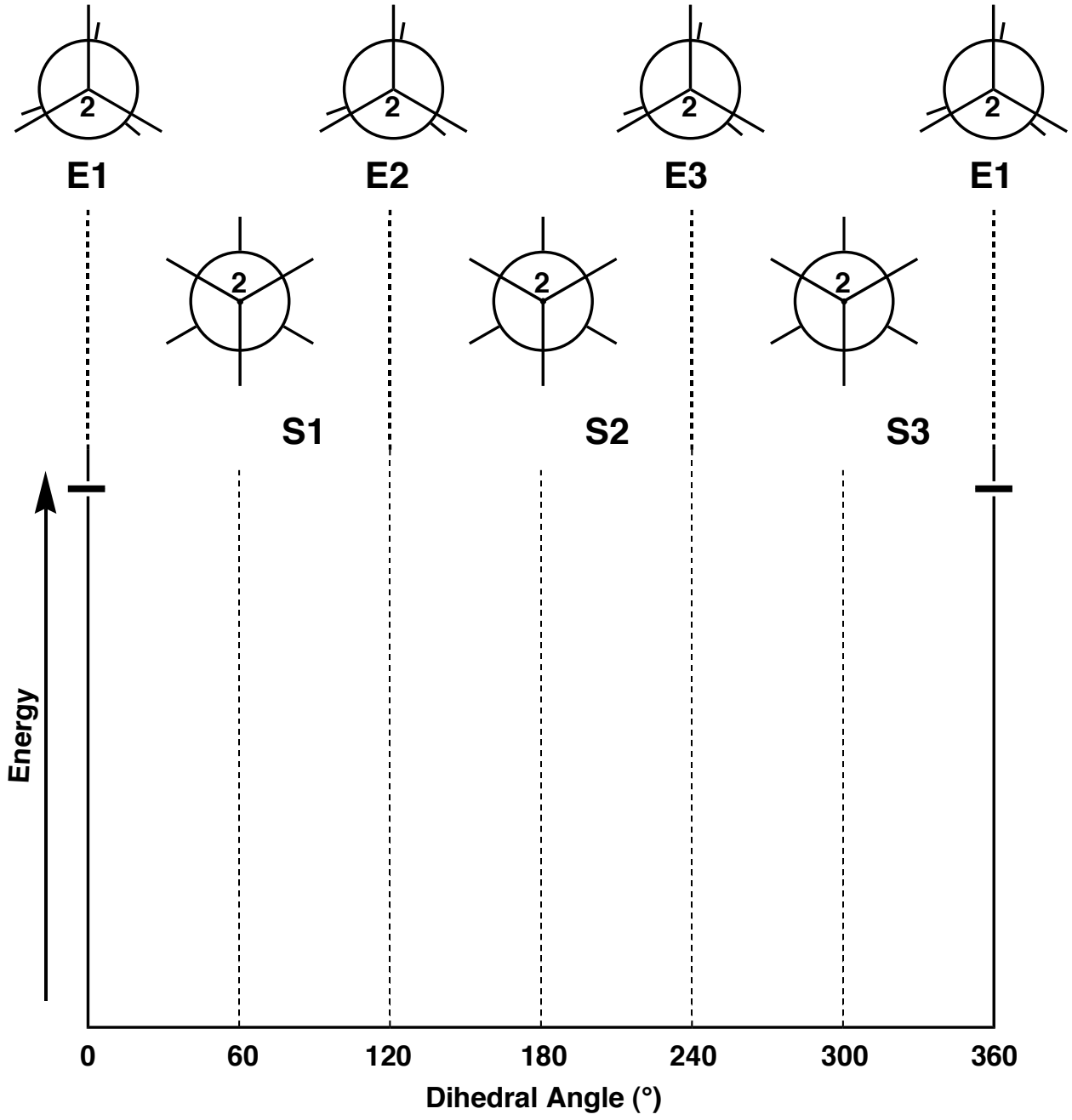
(e) One of the constitutional isomers of C_4H_9Cl can exist in two stereoisomeric forms (enantiomers). Draw these two non-superimposable mirror images in the appropriate boxes below. (2 pt each)

(*R*)-Enantiomer

(*S*)-Enantiomer

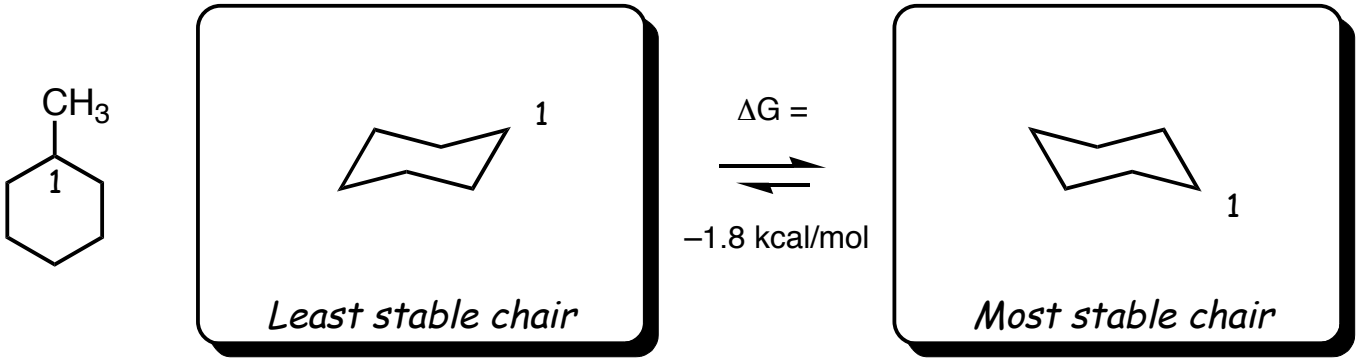
Q2. (a) Above the 0° line on the graph below, fill in the groups on the Newman projection of the **MOST UNSTABLE** eclipsed conformation (**E1**) of 2,3-dimethylbutane, as viewed from C2 to C3, i.e., C2 is in the front. By rotating C2 (and the groups attached to it) 60° **CLOCKWISE**, the first staggered conformation (**S1**) is reached, fill in the groups on this Newman projection above the 60° line. Continue this clockwise rotation, and complete the Newman projections of the other eclipsed (**E2**, **E3**) and staggered (**S2**, **S3**) conformations. (2 pt each)



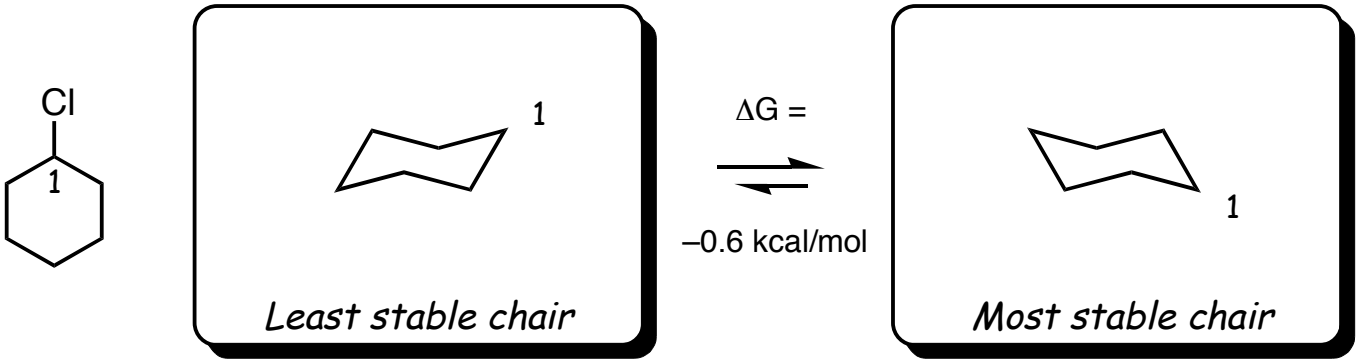


(b) Draw short horizontal bars on the **GRAPH ABOVE** (like those drawn for **E1** at 0° & 360°), indicating the relative energies of **S1**, **E2**, **S2**, **E3**, and **S3**, and complete the graph by drawing in a curve that shows how the energy changes relative to the dihedral angle. (6 pt)

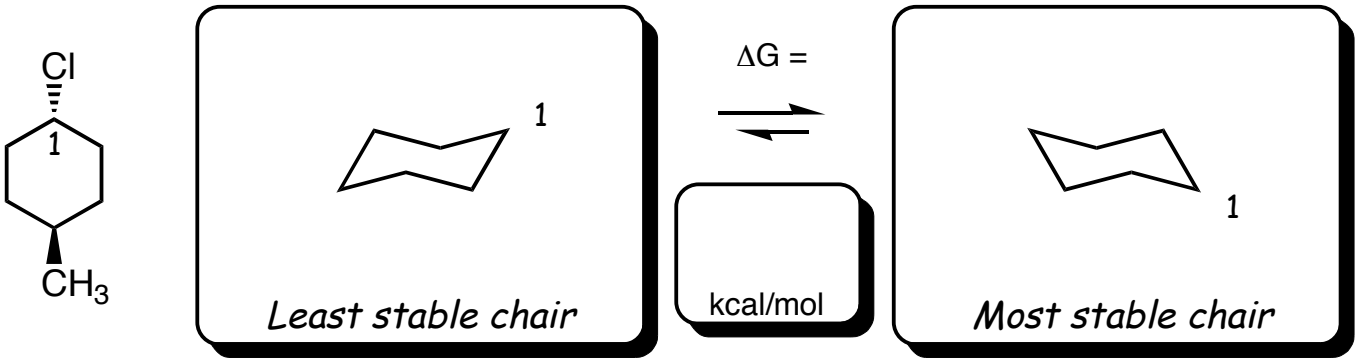
Q3. (a) Methylcyclohexane can exist in two different chair conformations, one of which is 1.8 kcal/mol more stable than the other, i.e., the **A value** for the methyl group is 1.8. In each of the two boxes below, draw in a bond to one methyl (**CH_3**) group in the appropriate position. (2 pt)



(b) Chlorocyclohexane also exists in two different chair conformations, one of which is 0.6 kcal/mol more stable than the other, i.e., the **A value** for the chloro group is 0.6. In each of the two boxes below, draw in a bond to one chloro (**Cl**) group in the appropriate position. (2 pt)

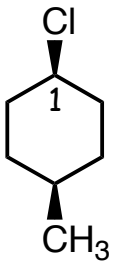


(c) For *trans*-1-chloro-4-methylcyclohexane (shown below), draw in bonds to **CH_3** and **Cl** groups as appropriate, to indicate the least and most stable chair conformers. Assuming that **A values** are additive (and hence subtractive if necessary...), predict what the ΔG value will be. (6 pt)



Question 3 *is continued on the next page...*

(d) For *cis*-1-chloro-4-methylcyclohexane (shown below), draw in bonds to **CH_3** and **Cl** groups as appropriate, to indicate the least and most stable chair conformers. Assuming that **A values** are additive (and hence subtractive if necessary...), predict what the ΔG value will be. (6 pt)



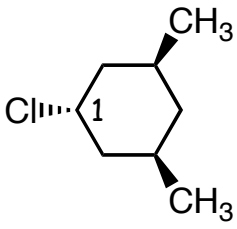
Least stable chair

ΔG =

kcal/mol

Most stable chair

(e) For the isomer of 1-chloro-3,5-dimethylcyclohexane shown below, draw in bonds to **CH_3** and **Cl** groups as appropriate, to indicate the least and most stable chair conformers. Assuming that **A values** are additive (and hence subtractive if necessary...), predict what the ΔG value will be. (8 pt)



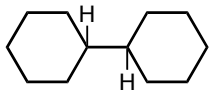
Least stable chair

ΔG =

kcal/mol

Most stable chair

(f) In the appropriate boxes below, draw the three most stable conformations of cyclohexylcyclohexane (shown to the right) in which the indicated H atoms maintain an **ANTI** relationship, i.e., are 180° apart. Once you have drawn these three **different** conformers, use the box below them to briefly explain your answers. (12 pt)



Cyclohexylcyclohexane

Most Stable Conformer

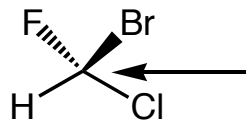
2nd Most Stable Conformer

3rd Most Stable Conformer

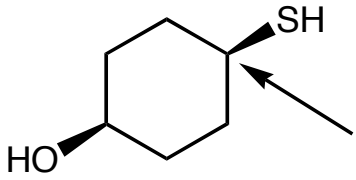
Explanation:

Q4. (a)–(f) In each box, write down either **R**, **S**, or **X**, indicating that the carbon atom to which the arrow is pointing has the ***R*** configuration, the ***S*** configuration, or is (**X**) not a stereocenter. (3 pt each)

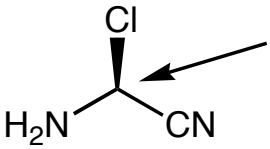
(**a**)



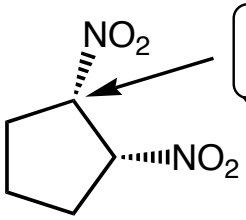
(**b**)



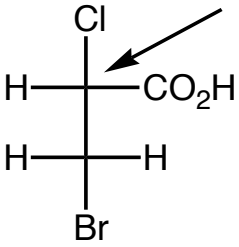
(**c**)



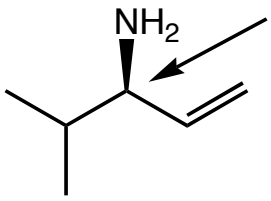
(**d**)



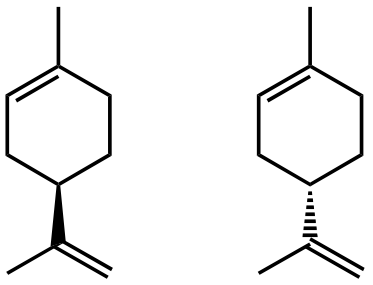
(**e**)



(**f**)

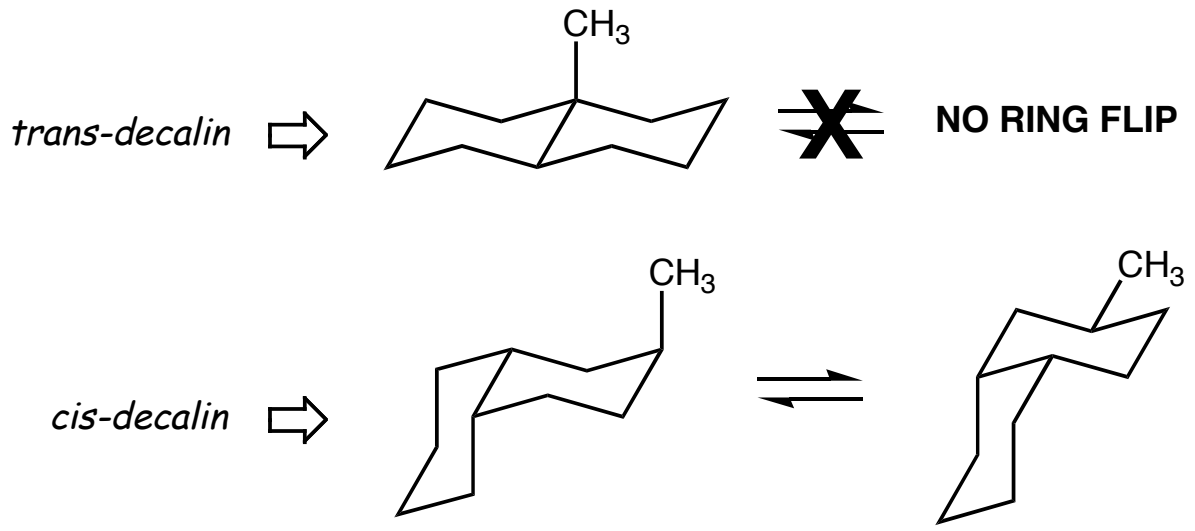


(g) The two enantiomers of limonene have **EXACTLY** the same boiling point, melting point, vapor pressure, and appallingly bad solubility in water. Interestingly, one of them smells of oranges (the *R* isomer) and the other (the *S* isomer) smells like lemons. Explain why they smell different. (4 pt)

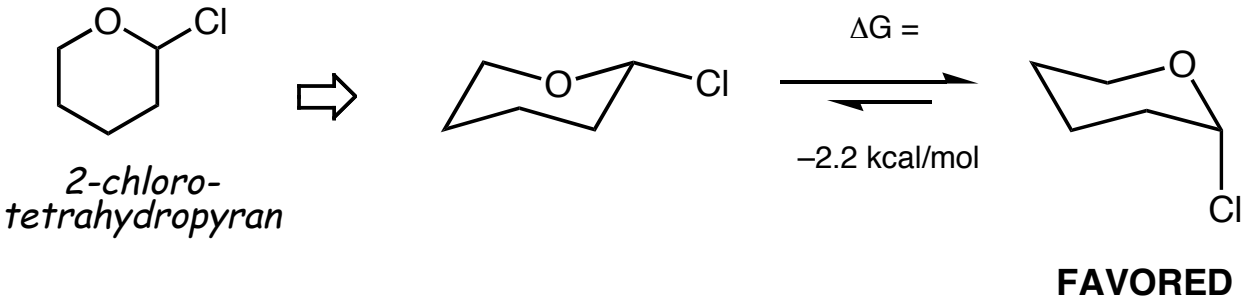


(*R*)-limonene (*S*)-limonene

Q5 (BONUS). Explain why trans-decalin systems cannot undergo chair flips, whereas cis-decalin systems can (examples are shown in the box below). (5 pt)



Q6 (BONUS). You've already seen that a chloro-substituent on a cyclohexane ring prefers to be in the equatorial position, i.e., the conformer with the Cl in the **EQUATORIAL** position is favored by 0.6 kcal/mol. Suggest why in the case of 2-chlorotetrahydropyran (shown below), the conformer in which the Cl atom is in the **AXIAL** position is favored by over 2 kcal/mol. (10 pt)



2-chloro-tetrahydropyran

FAVORED