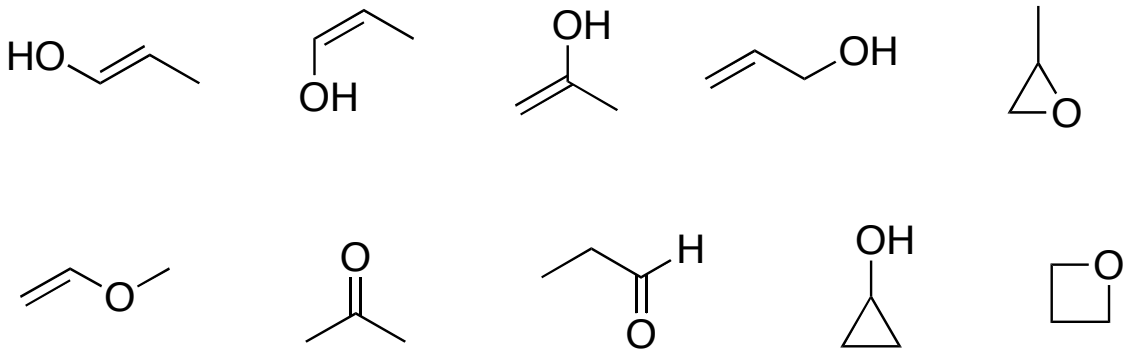
Chemistry 350
Exam 1 Answers- February 27, 2008

Problem 1. (15 points)
(i) (10 points) Provide structures of all isomers that have the formula **C_3H_6O**. For each isomer, all atoms must have complete octets and zero formal charge. There may be more or fewer boxes than isomers.

1 pt for each correct isomer



(ii) (5 points) List the names of the functional groups found in your drawings (list each functional group only once, no matter how often it appears):

alcohol
alkene
ether
ketone
aldehyde

1 pt for each functional group

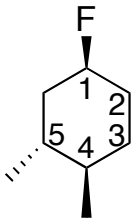
Problem 2. (15 points) For each molecule (parts A - C):

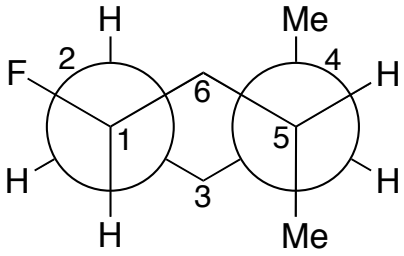
(i) **Fill in the substituents on the Newman projections** for the two possible cyclohexane chair conformations, including hydrogen atoms.
(ii) Circle the conformer that is **Lower** in energy (more stable).

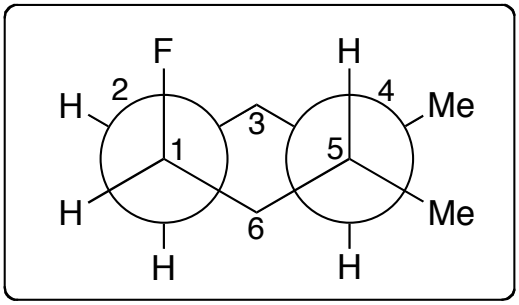
Use the templates provided to draw the Newman projections. The molecules and the templates are numbered. Make sure to fill in the Newman projections using the numbering scheme that matches the given structure. You do not need to fill in the hydrogen atoms on C3 and C6.

2 pts for each completely correct Newman, 1 pt if one mistake in a Newman
1 pt for correct circle

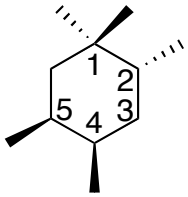
A) (5 points)

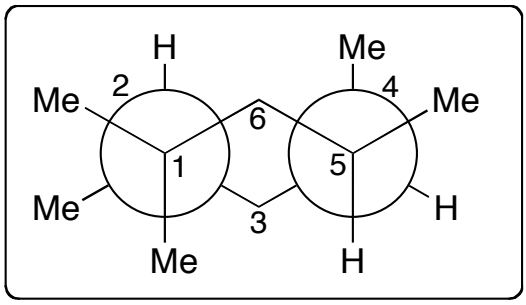


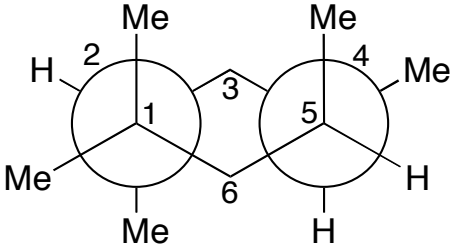




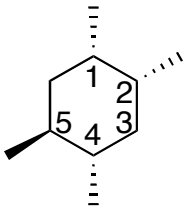
B) (5 points)

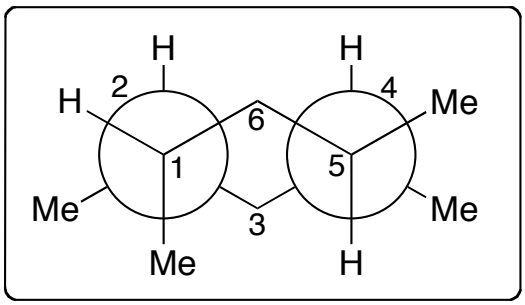


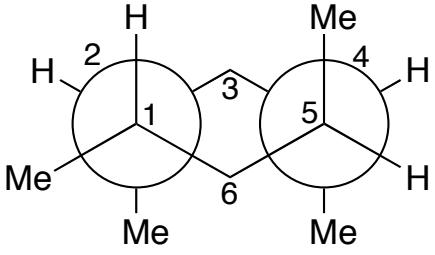




C) (5 points)

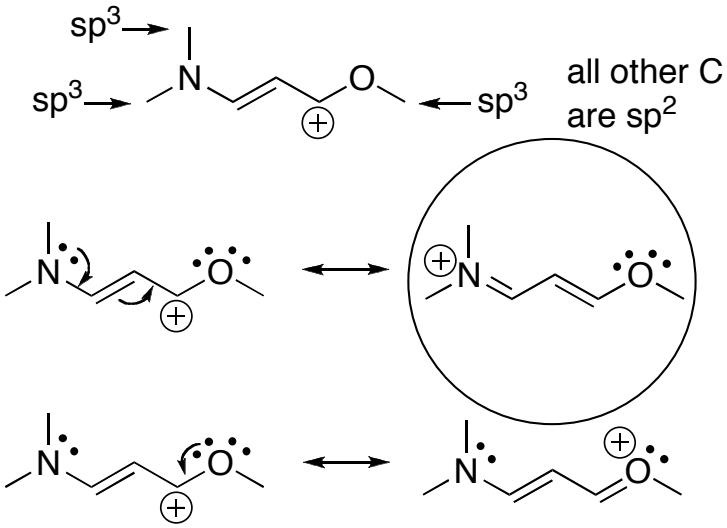






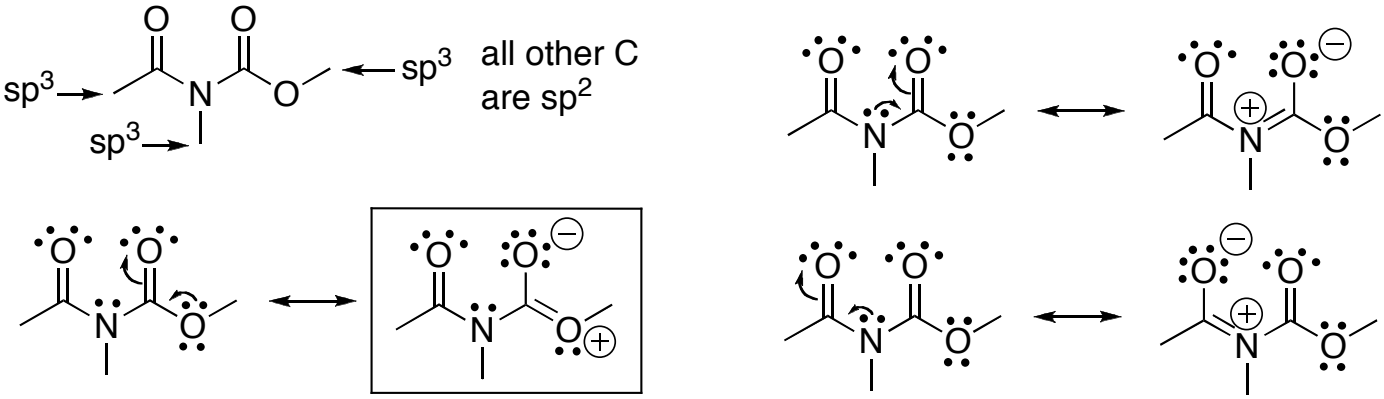
Problem 3 (22 points) In parts A - C, **draw all lone pairs and all formal charges.**

A) (6 points) Draw all resonance structures for the molecule shown below that have **full octets** on all atoms other than hydrogen. **Draw in arrows** to show how the electrons move to get from one resonance structure to the next. On the original structure that we provide, **indicate the correct hybridization** (sp^3, sp^2, or sp) of all carbon atoms. **Circle the structure** that is **lowest** in energy (most stable).



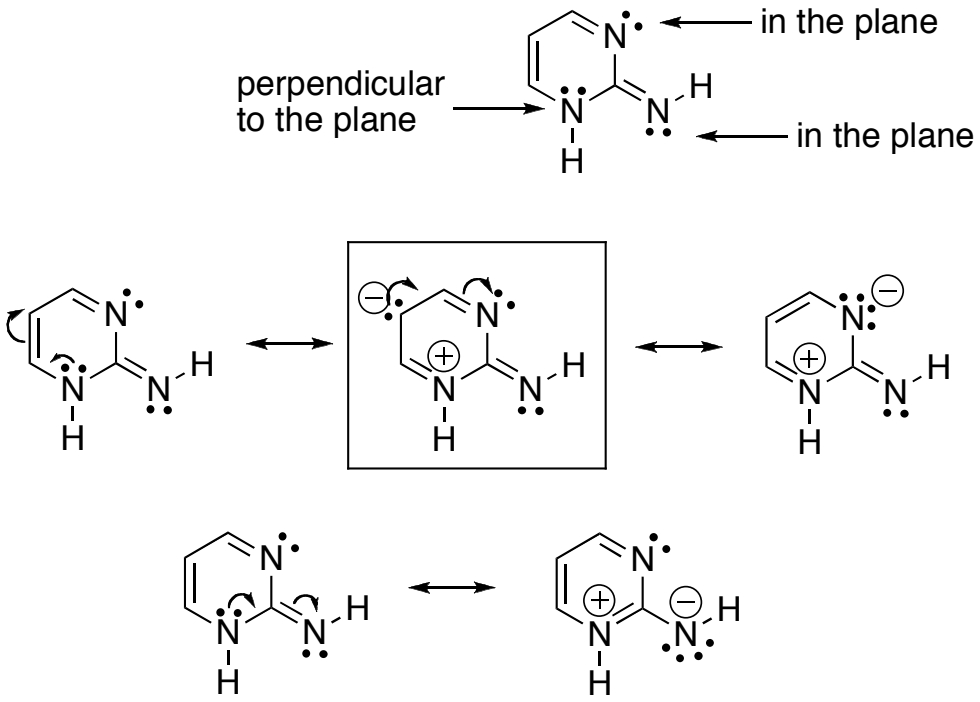
1 pt for each completely correct structure (2 pts total)
1 pt for each set of correct arrows (2 pts total)
1 pt for all correct hybridizations
1 pt for correct circle

B) (8 points) Draw all resonance structures for the molecule shown below that have **full octets** on all atoms other than hydrogen. **Draw in arrows** to show how the electrons move to get from one resonance structure to the next. On the original structure that we provide, **indicate the correct hybridization** (sp^3, sp^2, or sp) of all carbon atoms. **Put a square around the structure** that is **highest** in energy (least stable).



1 pt for each completely correct structure (3 pts total)
1 pt for each set of correct arrows (3 pts total)
1 pt for all correct hybridizations
1 pt for correct square

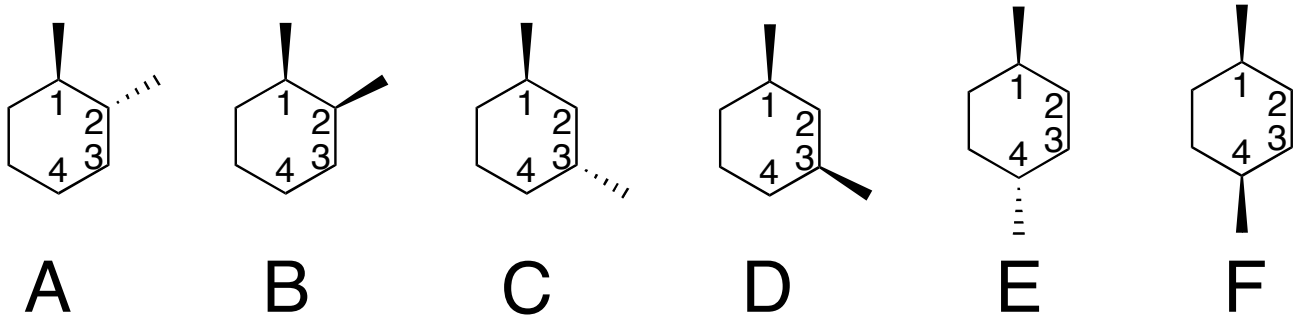
C) (8 points) Draw all resonance structures for the molecule shown below that have **full octets** on all atoms other than hydrogen. **Draw in arrows** to show how the electrons move to get from one resonance structure to the next. On the original structure that we provide, indicate for each nonbonding electron pair if it is in the plane of the paper (x,y plane) or perpendicular to the plane (z axis). **Put a square around the structure** that is **highest** in energy (least stable).



1 pt for each completely correct structure (3 pts total)
1 pt for each set of correct arrows (3 pts total)
1 pt for all correct in plane/perpendicular to the plane anwers
1 pt for correct square

Problem 4. (20 points)

Shown below are six different isomers of dimethylcyclohexane; each isomer has been assigned a letter.



For each of the six isomers, a pair of cyclohexane templates are provided, along with the corresponding energies of the two chair conformations. Your job is to use the energies of these chair conformations to assign the correct isomer (as identified by its letter) to the correct pair of templates.

Once you have assigned an isomer, fill in the two cyclohexane chair templates so that they match the energies that are provided. For some isomers the two chair conformations have the same energies. In these cases it does not matter which template you use for the two conformations. The information below will help you with these assignments.

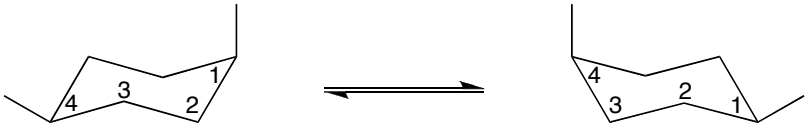
Me/Me gauche interaction = 0.9 kcal/mol
ΔG for interconversion of methylcyclohexane chair conformations (equitorial to axial) = 1.7 kcal/mol

When you fill in the chair templates you must draw, unambiguously, the methyl groups in the proper equatorial or axial positions. The molecules and the chair templates are numbered. Make sure to draw the chair conformations using the numbering scheme that matches the given structure.

The first isomer has been assigned for you to provide an example of how you should answer this problem. You can only use each isomer once, so don't use isomer **F** for any of your answers.

F

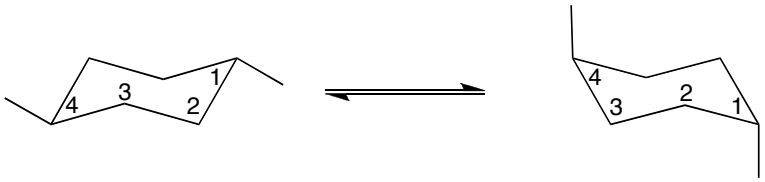
isomer letter



1.7 kcal/mol 1.7 kcal/mol

E

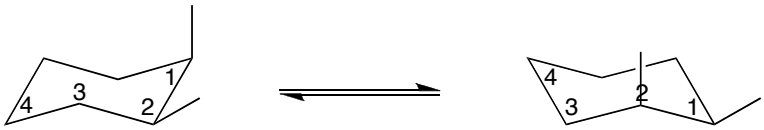
isomer letter



0.0 kcal/mol 3.4 kcal/mol

B

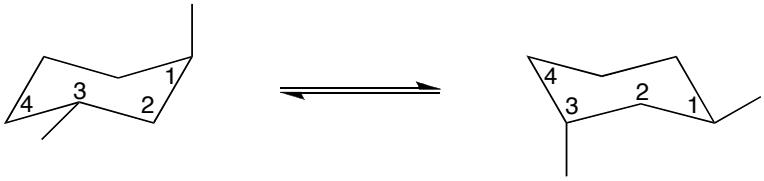
isomer letter



2.6 kcal/mol 2.6 kcal/mol

C

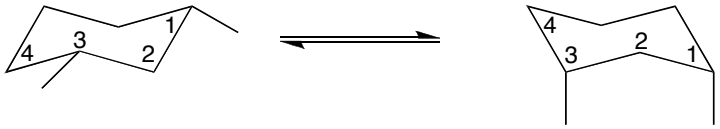
isomer letter



1.7 kcal/mol 1.7 kcal/mol

D

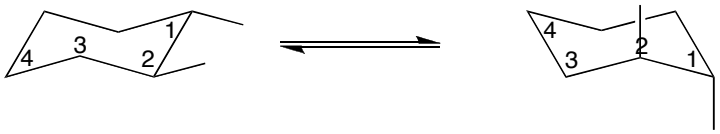
isomer letter



0.0 kcal/mol >3.4 kcal/mol

A

isomer letter

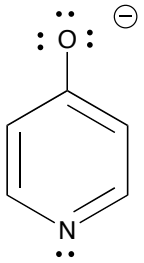


0.9 kcal/mol 3.4 kcal/mol

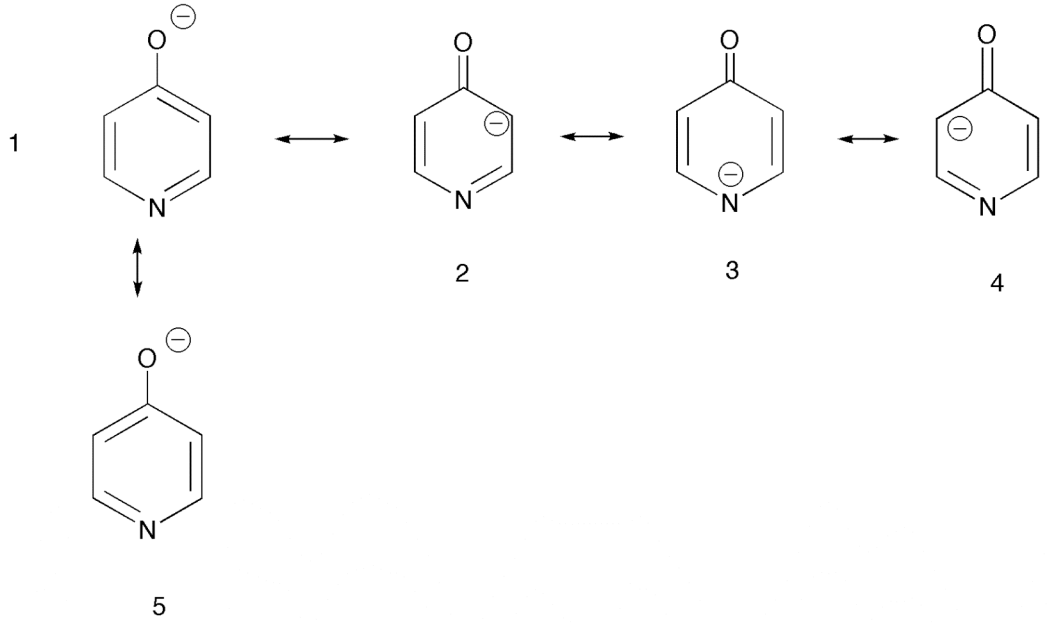
3 pts for each pair of correct structures. Axial and equatorial positions of the methyl groups must be unambiguous. 2 pts if there is a single mistake in the two structures. 0 points if there is more than a single mistake in the two structures.
1 pt for each correct letter

Problem 5. (10 points)

A) (8 points) Draw all important contributing resonance structures for



B) (2 points) Circle the structure or structures that are **Lowest** in energy (including the original structure that is provided).

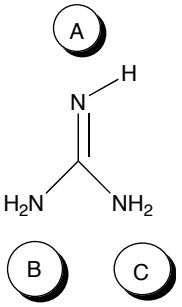


Two points each for structures 2, 3, 4, 5 (we gave them 1)

Two points for circling 1 and 5. One point if only 1 or 5 is circled. No points for anything else.

They do not have to show lone pairs on O, N or the anionic carbon but if they do it is ok. If they have extra structures in addition to the correct ones, subtract one point for each one, up to the number of right structures.

Problem 6. (10 points)

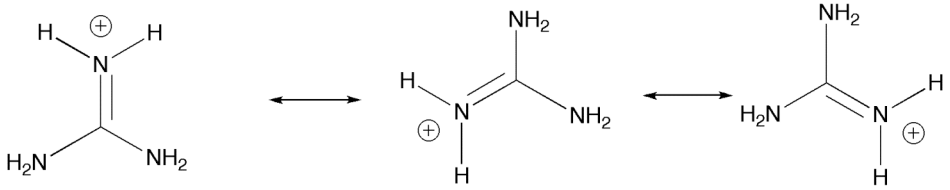


A) (3 points) Add a H^+ to nitrogen **A** (making it a NH_2^+ group) and draw all contributing resonance structures, if any.

B) (3 points) Add a H^+ to nitrogen **B** (making it a NH_3^+ group) and draw all contributing resonance structures, if any.

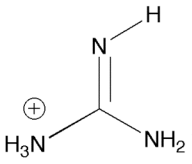
C) (4 points) Which structure is lower in energy, the one formed in part A or part B? Briefly explain your answer.

A)



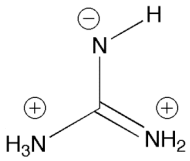
1 point 1 point 1 point

B)



3 points

if



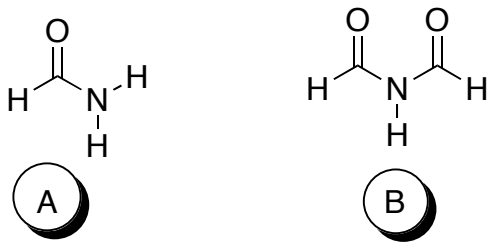
is drawn, that is ok but no points given or taken away.
If any other structures are drawn, take one point away if the right answer was given, to a maximumof three points. So, lowest score is 0.

C) Structure A Give 2 points

Explanation (2 points) Structure in A has MORE RESONANCE STRUCTURES or IT IS SYMMETRIC or DELOCALIZATION STABILIZES MOLECULES or related ideas

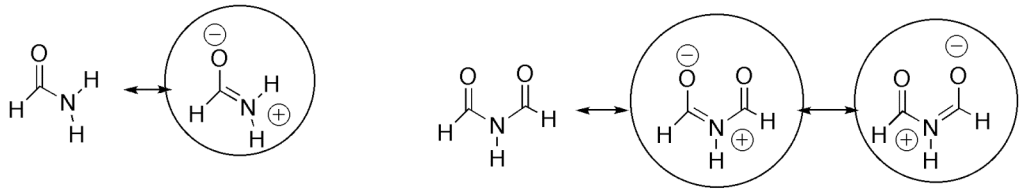
Problem 7 (8 points)

Which compound, A or B would you expect to have a **Shorter** C=O bond? Explain your answer, using diagrams if possible and 40 words or less.



B ONE POINT

2 POINTS FOR EACH CIRCLED RESONANCE STRUCTURE



EXPLANATION (one point) B has three resonance structures. Each C=O bond is one-third single and two-thirds double. In A the C=O is one-half single and one-half double. Since double bonds are shorter than single bonds, B would have the shorter bonds.