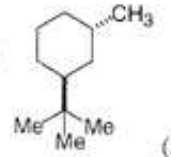
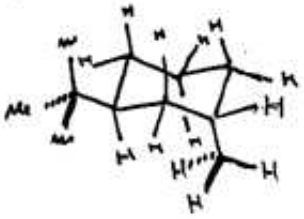
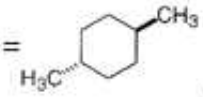
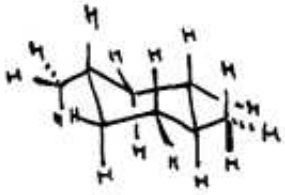
1) Draw molecules **A** and **B** in their lowest energy conformation. Draw EVERY hydrogen on the cyclohexane rings and on the CH_3 groups (you don't have to draw the hydrogens on the groups labeled "Me") Be sure that all the bonds that are supposed to be parallel are parallel. If your structures are not drawn neatly, points will be deducted (15 points total).

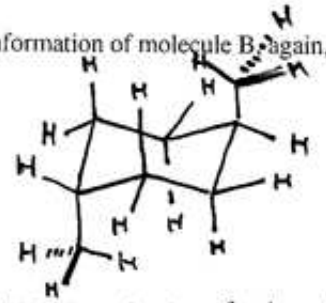
A = 

A) (5 points) 

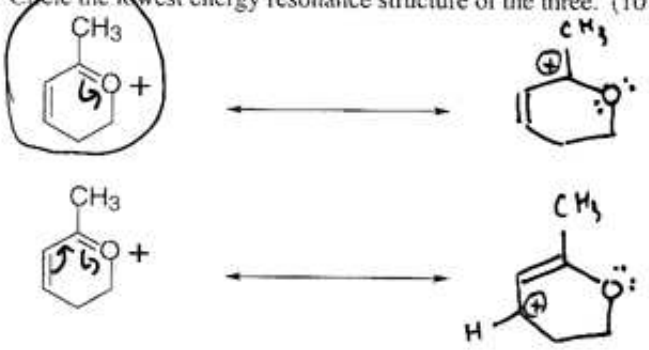
B = 

b) (5 points) 

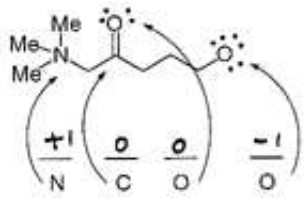
c) Now, draw the chair flip conformation of molecule B, again, with all the hydrogens included.



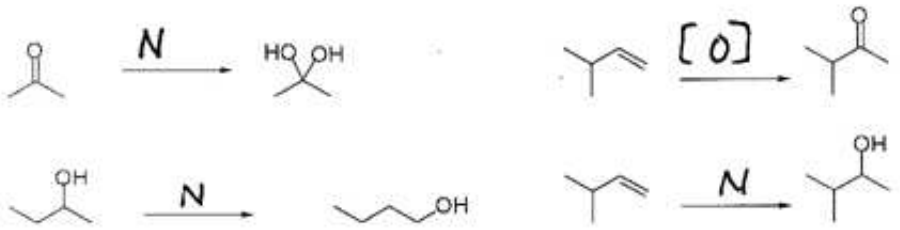
2) Of the three most important resonance structures for the molecule shown below, one is drawn.
a) Draw the other two. Be sure to include all lone pairs and charges in your answers.
b) Draw arrows showing how each of the two resonance structures you drew can be derived from the one I drew.
c) Circle the lowest energy resonance structure of the three. (10 points total)



3) What is the formal charge of each of the indicated atoms (all lone pairs are shown)?(8 points)

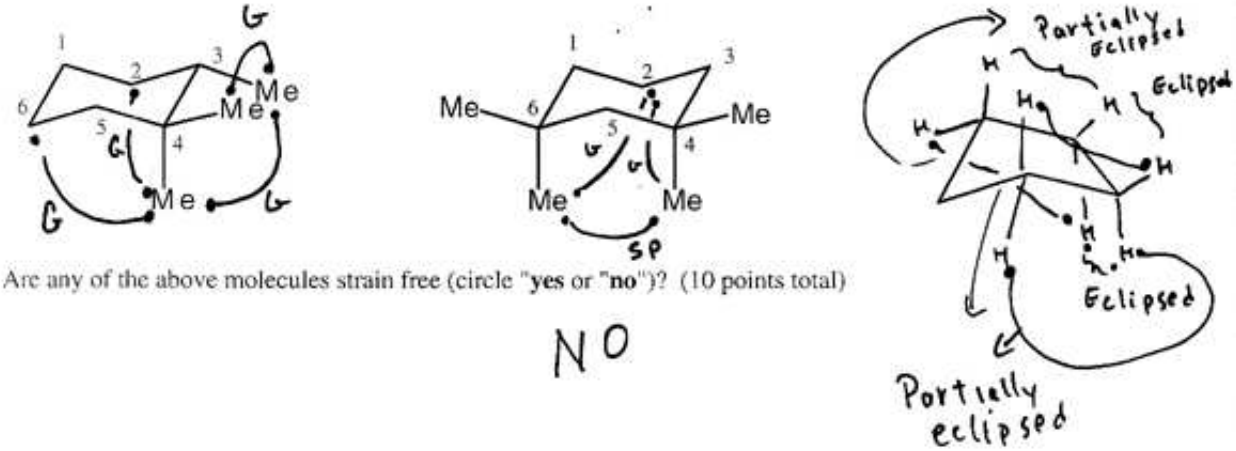


4) Are the following transformations oxidations, reductions or neither? (8 pts total)



5) Draw a Newman projection looking along the C-4 - C-3 bond of the molecule shown below. In your Newman projection, be sure that C-4 is in front and that the bonds are oriented in the same way as in the cyclohexane molecule (6 points)

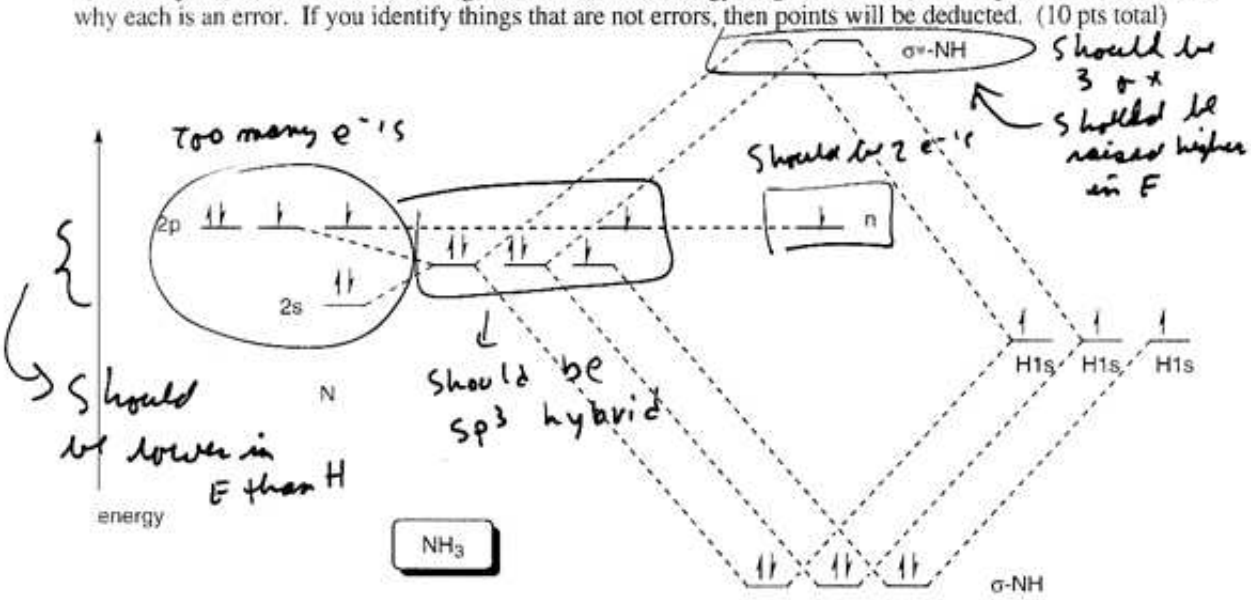
6) Identify all the interactions that contribute to the strain energy of the molecules shown below by indicating the carbons involved in the interaction, and by labeling the kind of interaction it is . Points will be deducted if you draw arrows between carbons that are not part of an interaction. If there are no interactions, then say so.



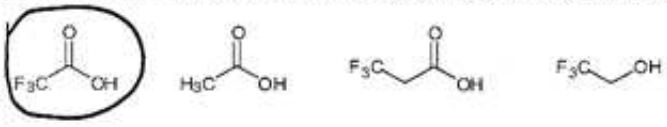
Are any of the above molecules strain free (circle "**yes** or "**no**")? (10 points total)

NO

7) Identify five errors in the following molecular orbital energy diagram for NH_3 and explain in one sentence why each is an error. If you identify things that are not errors, then points will be deducted. (10 pts total)



8) Circle the most acidic compound in each set shown below (6 points total).

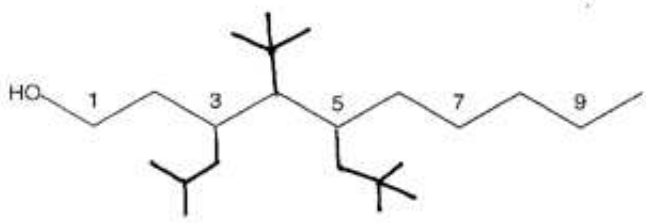
a) Set #1: 

b) Set #2: $^{+}NH_4$ H_3O^{+} CH_4 NH_3 $^{-}CH_3$

c) Set #3: H_2O BH_3 NH_3 $^{-}CH_3$

9) Draw the following substituents on the carbon chain shown below (6 points):

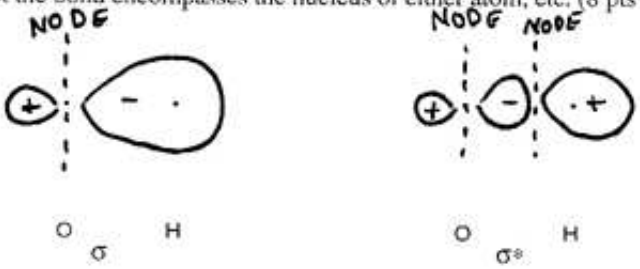
an *iso*-butyl group at C-3
a *tert*-butyl group at C-4
a *neo*-pentyl group at C-5



10) Define strain energy in one sentence (4 pts).

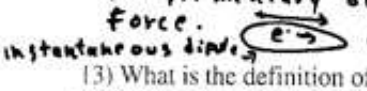
(The energy of a molecule) - (the energy of a hypothetical strain free molecule)

11) Draw pictures of a σ-orbital and σ*-orbital (i.e., draw pictures of the orbitals, not energy diagrams) for one of the O-H bonds in water. Please be precise in your drawing, and indicated the presence of any nodes and whether or not the bond encompasses the nucleus of either atom, etc. (8 pts total)



12) Explain why hexane has a higher boiling point than pentane. In your explanation, describe each force that is involved in keeping the molecule in the liquid phase, and explain how this force operates. You should draw the molecules as simple ovals and explain the interaction for each force that is responsible as I did in class. If only one force is operative, then you only have to draw one picture Use only the space provided below (5 pts).

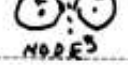
Hexane has a higher B.P. due to greater van der Waals interaction. The electrons in a hexane molecule are moving, and at any instant, a particular molecule has a dipole ("instantaneous dipole"). This induces a complementary dipole in neighboring molecules, which creates an attractive force.



} New dipole. The larger the molecule, the greater the separation of charge, the stronger the force.

13) What is the definition of an antibonding orbital? In your answer explain the role of any nodes in the orbital and the orientation of the nodes with respect to the atoms. You may draw a picture if it would help your explanation. Use only the space provided below (4 pts).

An anti bonding orbital is a molecular orbital which is composed of the overlap of two atomic orbitals ~~with~~ in an out of phase combination (destructive interference) such that there is a between the two nuclei:



} H_2O *

Have a safe trip home.