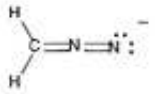
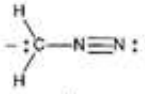
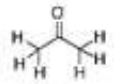
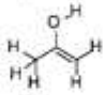
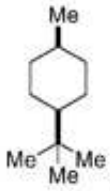
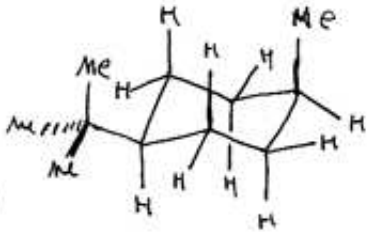
1) Are the following pairs of structures isomers, resonance structures, different conformations of the same molecule or none of the above? (3 points each).

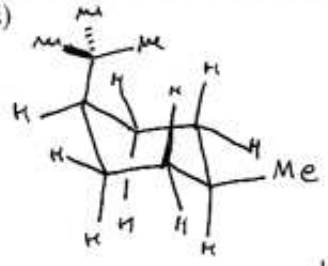
A)  and  Resonance

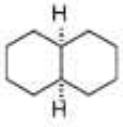
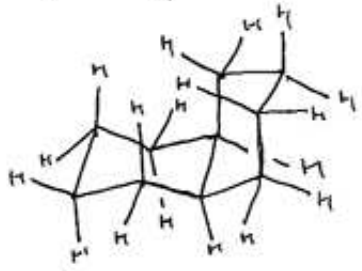
B)  and  Isomers

C)  and  Isomers

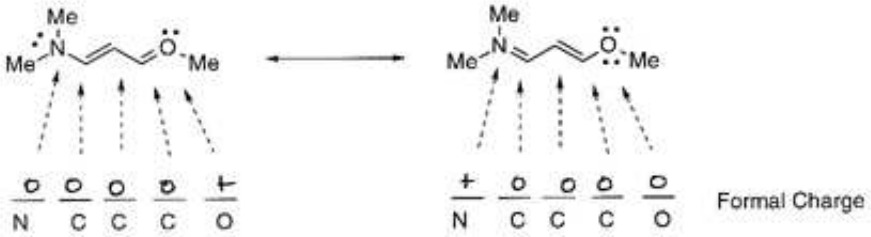
2) Draw the molecules A and C in their lowest energy conformation. Draw EVERY hydrogen on the cyclohexane rings and be sure that all the bonds that are supposed to be parallel are parallel. If you're structure is not drawn neatly, points will be deducted.

A) A =  (5 points) 

b) Now, draw the chair flip conformation of molecule A, again, with all the hydrogens drawn correctly, etc.(5 points) 

c) C =  (5 points) 

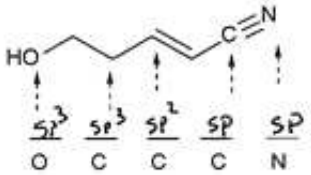
3) Below are two resonance structures.
A) What is the formal charge of each of the indicated atoms? (3 pts, -1 for each wrong answer)



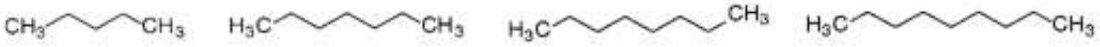
B) Draw arrows showing the movement of electrons to go from structure A to structure B
C) Draw arrows showing the movement of electrons to go from structure B to structure A
(4 pts each)

A B

4) What is the hybridization of each of the indicated atoms in the structure shown below? (3 pts, -1 for each wrong answer)



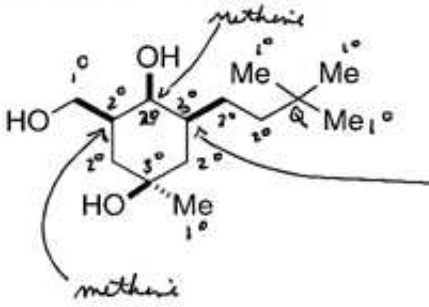
4) Alkanes have the suffix "ane" at the end of their names (i.e., methane, ethane, etc.). What are the names of the following (1 pt each):



Pentane heptane octane nonane

4) Draw an arrow to one of each kind of carbon in the molecule below (1 pt each):

1° carbon
2° carbon
3° carbon
quaternary carbon



Methyl carbon
methylene carbon
methine carbon

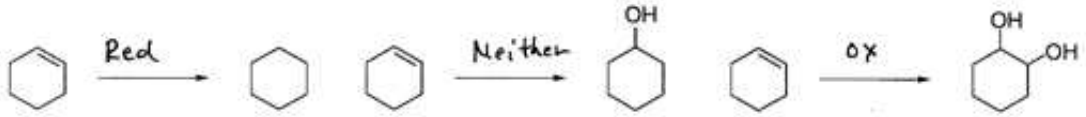
4a) Draw the product of the reaction shown below as well as an arrow pushing mechanism for this transformation (8 pts).

$HO^{(-)}$ + H–Cl ⟶

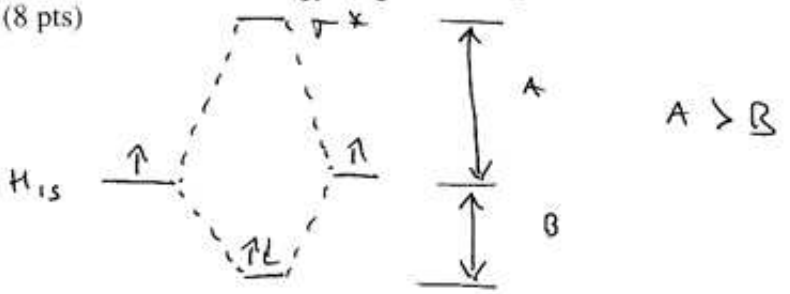
4b) In class 1 mentioned that in writing mechanisms, electrons always attack empty orbitals. What is the empty orbital being attacked in the above reaction? (2 pts)

σ^* H–Cl bond

5) Are the following transformations oxidations, reductions or neither? (6 pts)



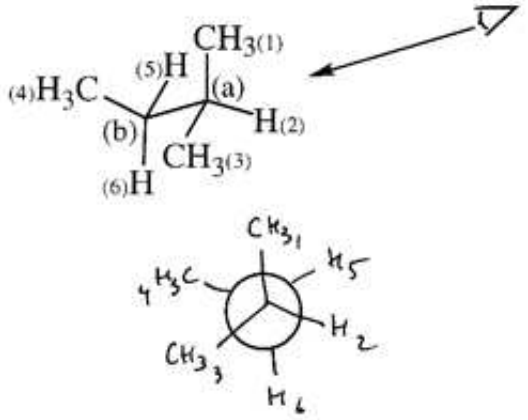
6a) Draw the molecular orbital energy diagram for H_2. Be sure that all the energy levels are correct. (8 pts)



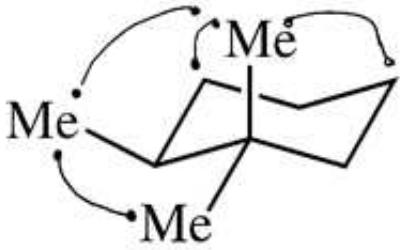
6b) The σ-orbital for H_2 is made up of two atomic orbitals. Draw these two atomic orbitals in the picture on the left, and then draw the resulting σ-orbital on the right. Be sure to indicate the sign of the wave function in your drawing. (6 pts)

6c) The σ*-orbital for each C-H bonds of methane is made up of two atomic orbitals. Draw these two atomic orbitals in the picture on the left, and then draw the resulting σ*-orbital on the right. Be sure to indicate the sign of the wave function in your drawings, and note that I'm only asking for you to draw the orbitals for one C-H bond. (6 pts)

7) Draw a Newman projection looking along the central C-C bond axis of the molecule shown below. In your Newman projection, be sure that C_a is in front and that you label the methyl groups and hydrogens (1 - 6) in your drawing as I have. (4 points)



8a) Identify all the interactions that contribute to the strain energy of the molecule shown below by drawing arrows between the carbons in the interactions. (8 pts)



8b) Does this molecule have any torsional strain (circle "yes or "no")? (2 pts) **YES** **NO**

9) In class on Wednesday, I was asked repeatedly if you would have to know nomenclature beyond what I indicated on the review sheet (i.e., iso- sec- neo- etc.), and I said that you would not. Were there any questions on this exam which required that you know this nomenclature (circle "yes" or "no")? hint: the correct answer is "no". (1 pt) **YES** **NO**