Question 1 (14 pts.)

a) Give a line-angle structure for the following condensed formula. Do not forget to add all non-bonding electrons where appropriate.

\[(\text{CH}_3\text{CH}_2)_2\text{CC(\text{CH}_2\text{CH}_3)}\text{CH}_2\text{COCH(\text{CH}_3)}\text{CCCHO}\]

Extra Credit (5 pts.) In the "Organic Chemistry in Real Life" pages, anti-bonding molecular orbitals were described as playing an important role in which of the following

- color
- burning hydrocarbons
- ATP energy conversion

Question 2 (27 pts.) Directly ON TOP of the structures below, draw a picture of the \(\Psi\) or \(\Psi^2\) as requested, for the indicated orbitals, AND, in each case write down the atomic orbital or orbitals that you used, as appropriate.

- \(\Psi\) for the C-O \(\pi^*\) M.O.

- \(\Psi^2\) for the C-Cl \(\sigma^*\) M.O.

- \(\Psi\) for the N-H \(\sigma\) M.O.

Question 3 (6 pts.) Give one property of electrons that can only be explained by taking into account their wave behavior.
Question 4 (22 pts.) For the structures A and B below:

a) State (in words, do not draw on top of the structures) which is the largest BOND DIPOLE moment(s) in A and which is the largest bond dipole moment(s) in B.

b) Between these two largest dipole moments (one from A and one from B), which would be larger? Give a brief explanation.

c) Draw the MOLECULAR DIPOLE MOMENTS ON TOP OF THE STRUCTURES. Your drawing does not need to illustrate the size of the dipole, only the direction. If there is no molecular dipole, indicate so.

d) Indicate which structure would have the larger MOLECULAR dipole moment, give a brief explanation.

\[ \text{A} \quad \text{N=CC=NN} \]
\[ \text{B} \quad \text{Br-F} \]

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Question 5 (14pts.) For the vinyl anion shown to the right:

a) give the hybridization for the circled carbon atom

b) state, in words, exactly what the various pairs of electrons around the circled atom "do", e.g. in a $\sigma$-bond to atom X, in a $\pi$-bond to atom Z, are non-bonding, etc.

c) list the hybridized valence orbitals for the circled carbon, and how these are used to accommodate the electron pairs mentioned in part b)
Question 6 (44 pts.) For the molecular formula C₄H₈O

a) Give the degrees of unsaturation

b) Draw SIX structural isomers that obey the normal rules of valence for each atom. Include all non-bonding electrons. You can draw Lewis structures or line-angle structures (your choice). If you draw line-angle structures, don't forget to include the H atoms that are normally included as part of the functional groups. CIRCLE AND IDENTIFY ALL FUNCTIONAL GROUPS IN YOUR STRUCTURES!!

c) Draw THREE PAIRS of stereoisomers that obey the normal rules of valence for each atom. Include all non-bonding electrons. You can draw Lewis structures or line-angle structures (your choice). If you draw line-angle structures, don't forget to include the H atoms that are normally included as part of the functional groups. DO NOT IDENTIFY THE FUNCTIONAL GROUPS THIS TIME!

DO NOT INCLUDE ANY STRUCTURES in part c) THAT WERE DRAWN AS PART OF YOUR ANSWER TO PART b) OF THIS QUESTION
Question 7 (24 pts.) Rank the pairs of electrons indicated, A, B, C, D and E in order of increasing energy. Give an explanation for your choice.

Question 8 (24 pts.)

a) Rank the bonds indicated A, B and C in terms of increasing bond dissociation energy, give a brief explanation.

b) Treat homolytic bond dissociation as a simple chemical reaction. For BOND A below, add the curved arrows to the structure that illustrate bond-breaking and show the products of homolytic bond breaking (i.e. what you get after breaking the bond) on the "product side" of the reaction arrow below.