

**NAME (Print):** \_\_\_\_\_

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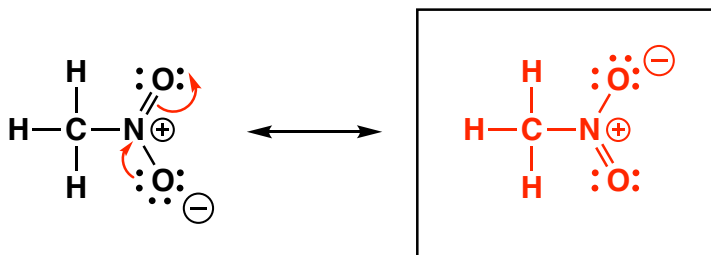
**Chemistry 320M/328M  
Dr. Brent Iverson  
2nd Homework  
September 4, 2024**

**Please print the  
first three letters  
of your last name  
in the three boxes**

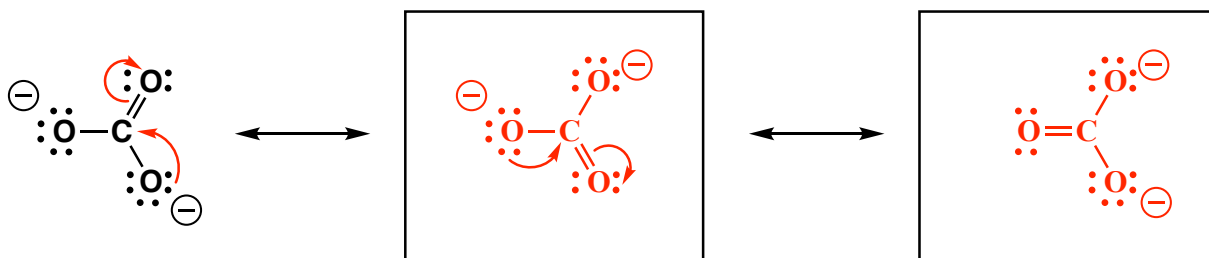
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1. (1 or 2 pts each) The following molecules are best represented as the hybrid of contributing structures. **Draw the most important contributing structures** in the spaces provided, including all lone pairs and formal charges. **For all but the structures on the right in each problem, use arrows to indicate the movement of electrons to give the structures you drew.** You might want to read these directions again to make sure you know what we want.

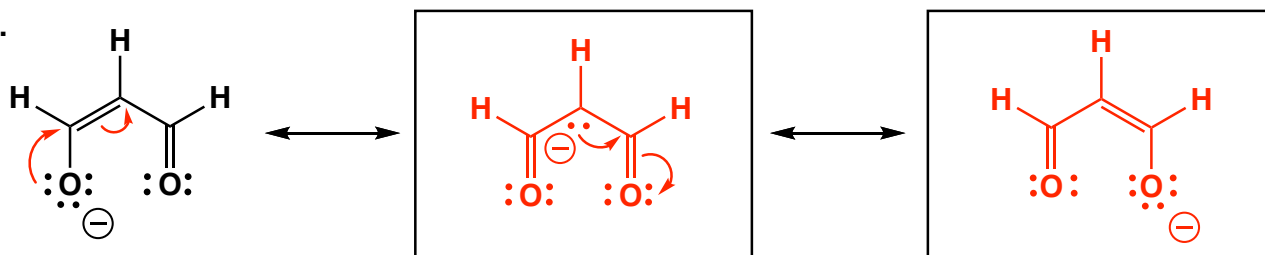
A.



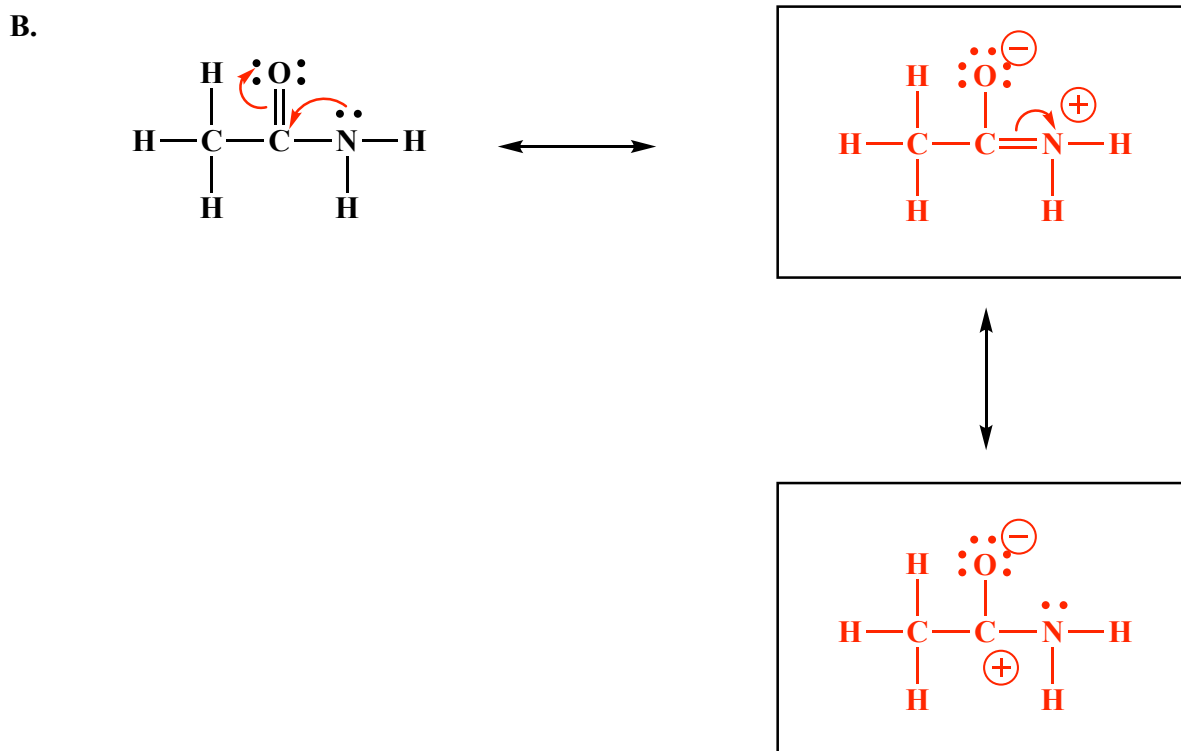
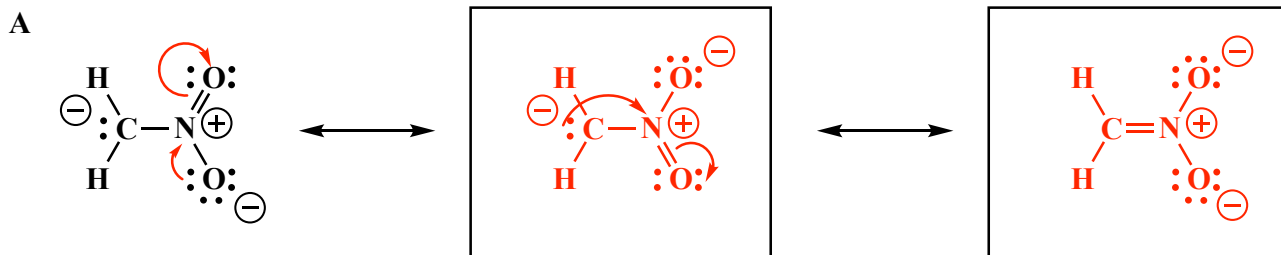
B.



C.



2. (2 pts each) The following molecules are best represented as the hybrid of three contributing structures. Draw the second and third important contributing structures in the spaces provided, including all lone pairs and formal charges. For the two structures on the left in each problem, use arrows to indicate the movement of electrons to give the structures you drew. You might want to read these directions again to make sure you know what we want.



3. (1 pts each) Fill in each blank with the word or words that best completes the sentences.

For organic chemistry, it is best to think of electrons as waves.

The electron density in molecules can be described mathematically by adding the wave functions of all the atomic orbitals for all the atoms in the entire molecule, an approach referred to as molecular orbital theory.

The wave functions for the valence atomic orbitals on each atom can be added together first, a process referred to as hybridization, before looking for overlap with orbitals from other atoms. This approach is called valence bond theory.

You need to be able to think about all sigma bonding in molecules as being derived from the overlap of hybridized orbitals and all pi bonding as being derived from overlap of unhybridized 2p orbitals.

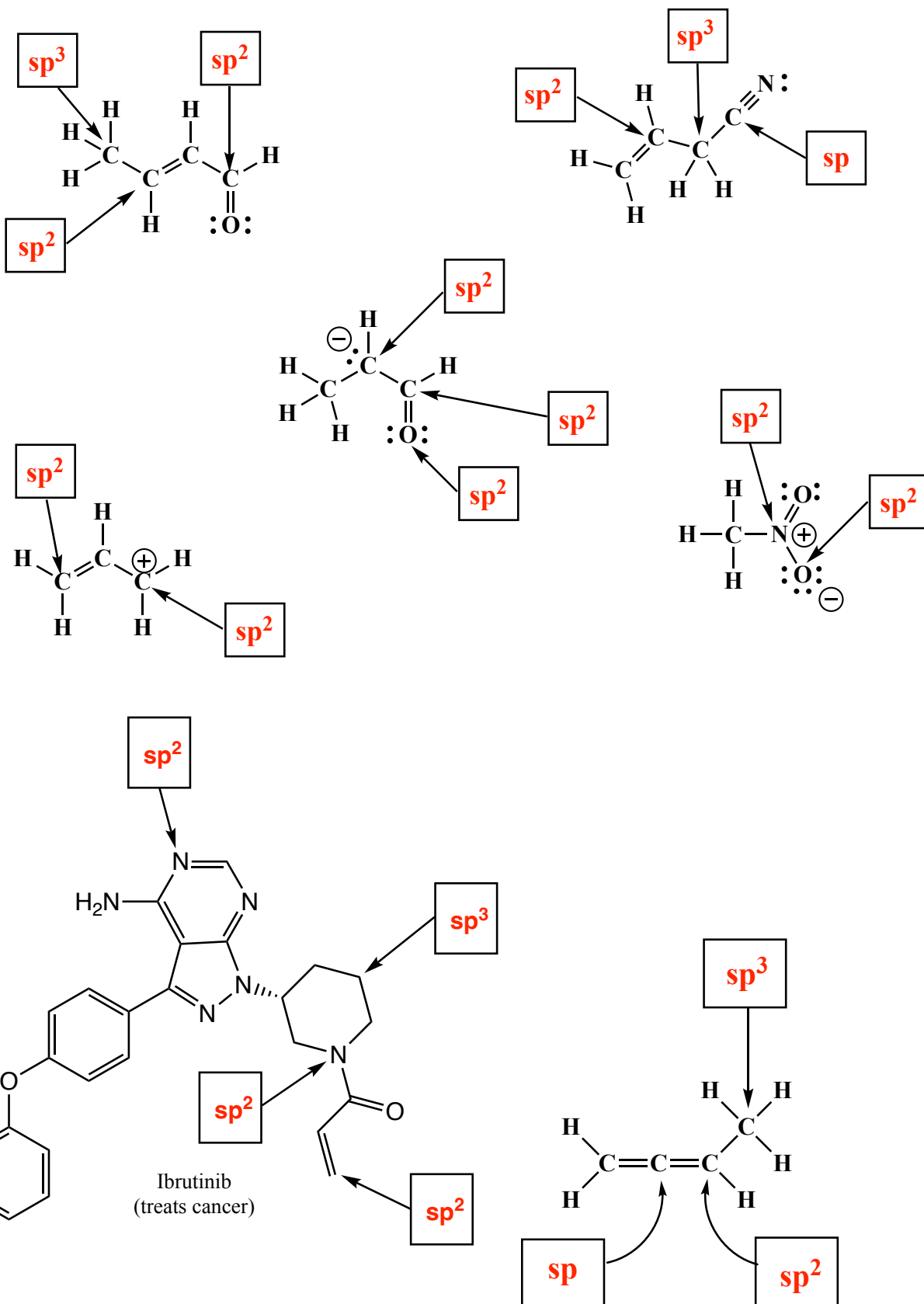
Three (or more) atom "pi-ways" are the situation resonance contributing structures are usually trying to describe. Individual Lewis structures can only describe pi bonding between two atoms, not three or more, explaining why the contributing structures are needed for these situations.

For pi bonding and therefore pi delocalization to occur over more than two atoms (i.e. pi-ways), parallel 2p orbitals are needed on ALL of the adjacent atoms involved, explaining why ALL of these atoms must be sp<sup>2</sup> (or sp) hybridized and why these systems are planar.

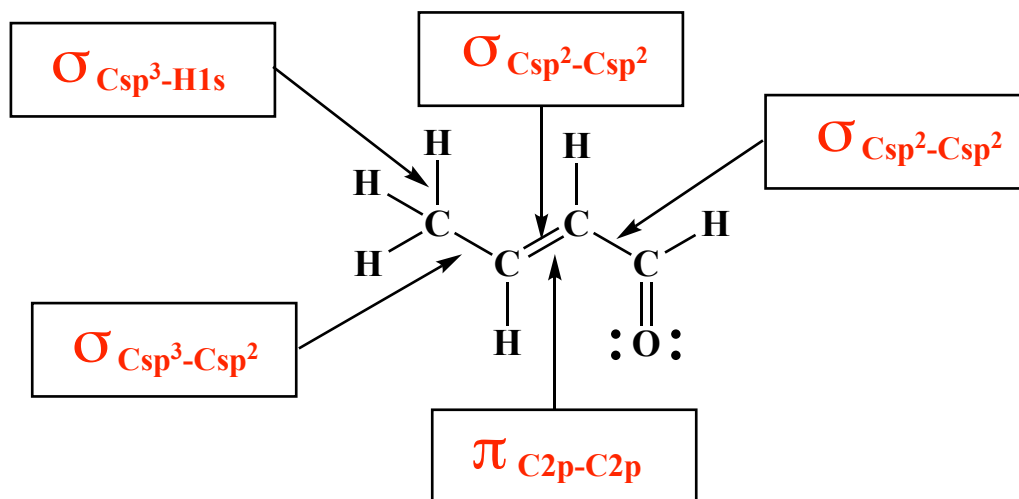
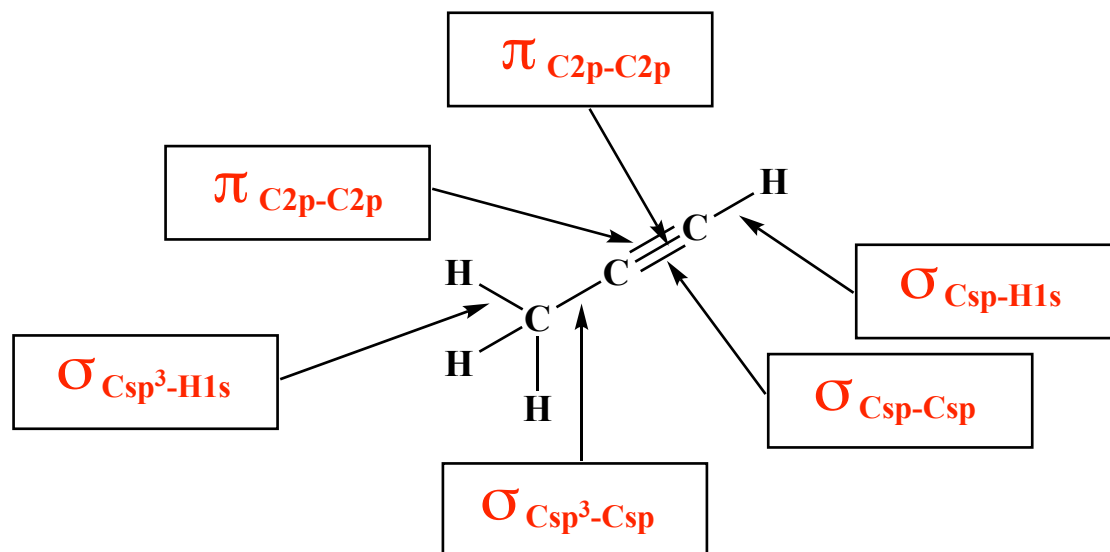
4. (1 pt each) For the following TRUE and FALSE questions, CIRCLE "T" FOR ALL OF THE TRUE STATEMENTS AND "F" FOR ALL OF THE FALSE STATEMENTS This is not meant to be tricky, but please read the statements carefully so that you do not make any careless errors. We are not attempting to trick you here with complicated statements, but you still might want to take your time on these.

- T  F A. Resonance contributing structures do not represent equilibrating structures, rather the hybrid (blending) of them is the true molecular representation.
- T  F B. When drawing resonance contributing structures you generally move atom nuclei and sigma bonds.
- T  F C. When drawing resonance contributing structures, you generally move pi bonds (*one* bond of a double or triple bond) and lone pair electrons, not atom nuclei or sigma bonds.
- T  F D. For organic chemistry, it is best to think of electron density as particles, described by Newton's laws.
- T  F E. For organic chemistry, it is best to think of electron density as waves, described by wave equations.
- T  F F. A C atom is  $sp^2$  hybridized if it has one pi bond and three sigma bonds
- T  F G. A C atom is  $sp$  hybridized if it has two pi bonds and two sigma bonds
- T  F H. A C atom is  $sp^3$  hybridized if it has four sigma bonds and no pi bonds
- T  F I. A sigma bond occurs when the majority of the electron density is found on the bond axis.
- T  F J. A pi bond occurs when the majority of the electron density is found on the bond axis.
- T  F K. A C atom is  $sp^2$  hybridized ONLY if ALL contributing structures have one pi bond and three sigma bonds.
- T  F L. A C atom is  $sp^3$  hybridized EVEN if ONLY one important contributing structure has one pi bond and three sigma bonds.
- T  F M. A C atom is  $sp^2$  hybridized EVEN if ONLY one important contributing structure has one pi bond and three sigma bonds.
- T  F N. When considering the pi bonding in an amide, remember that three 2p orbitals overlap to create two pi molecular orbitals involving only the O and N atoms.
- T  F O. When considering the pi bonding in an amide, remember that three 2p orbitals overlap to create three pi molecular orbitals involving the central C atom as well as the O and N atoms.
- T  F P. Molecular orbital theory is based on mathematically combining all of the component atomic orbitals in a molecule, creating new molecular orbitals that extend over the entire molecule.
- T  F Q. For this class, it is best to think of sigma bonds using molecular orbital theory, and pi bonds using valence bond theory.
- T  F R. For this class, it is best to think of sigma bonds using valence bond theory, and pi bonds using molecular orbital theory.
- T  F S. The most important question in chemistry is: Where are the electrons?

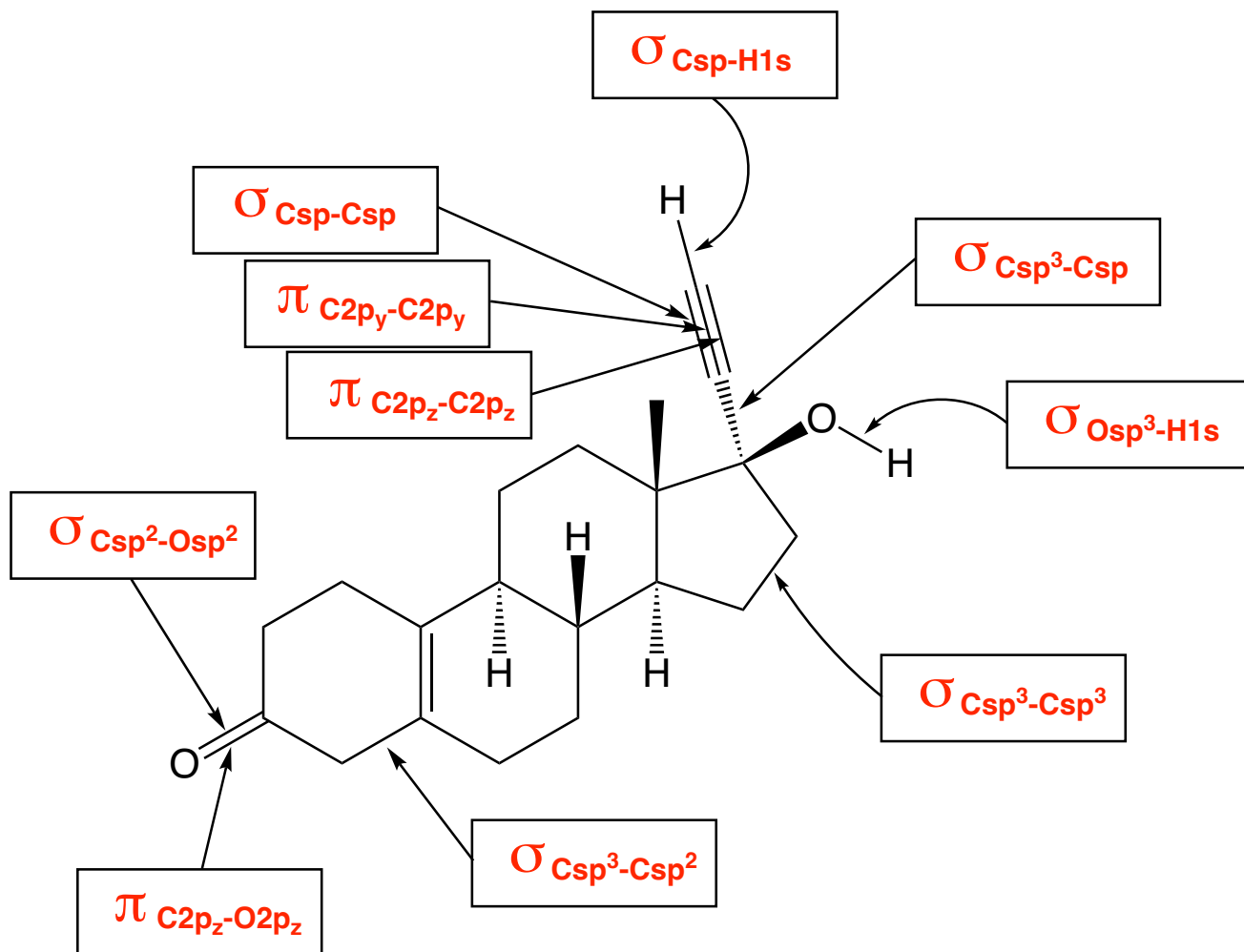
5. (20 pts) For the following molecules, write the hybridization state of each atom indicated by the arrow.



6. (11 pts) Describe each bond indicated with an arrow as the overlap of orbitals. For example, an answer might be  $\sigma_{\text{Csp}^3\text{-Csp}^3}$ .



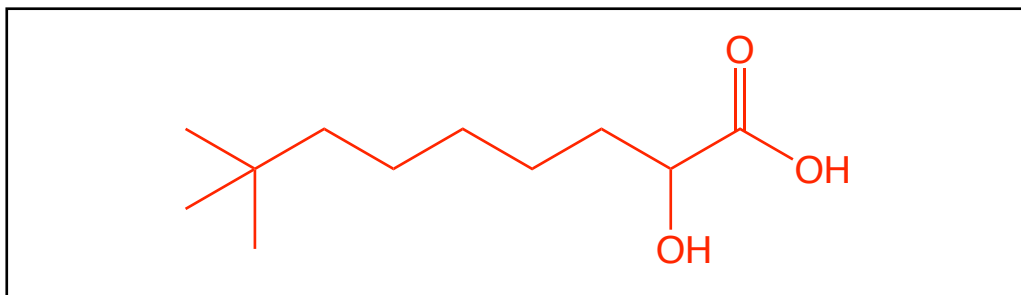
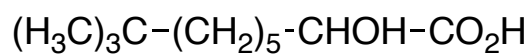
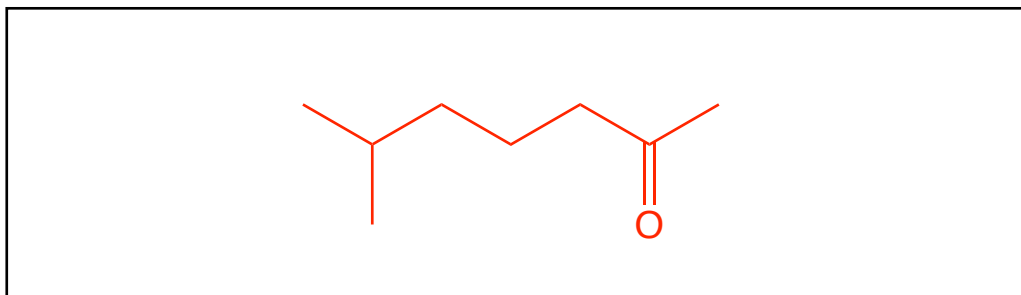
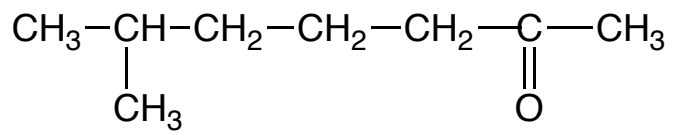
6. (cont). (10 pts)



Noretynodrel (a contraceptive)



7. (5 pts each) Draw the appropriate line-angle structures for the following molecules.



8. (1 pt each) In the space provided, write “rotates” if the bond indicated by the arrow can rotate freely at room temperature. Write “does not rotate” if the indicated bond cannot rotate at room temperature.

