

NAME (Print): _____

Chemistry 320M/328M
Dr. Brent Iverson
1st Midterm
September 26, 2024

EID _____

SIGNATURE: _____

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

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Please Note: Please take your time. We are giving you three hours to take this exam even though it is really a one hour exam. The idea is to give you enough time to show us what you know, not how fast you can draw structures. Please take all the time you need to draw the best possible structures that you can! Do not be surprised if you are comfortable leaving the exam long before 9 PM. That is to be expected!

FINALLY, DUE TO SOME UNFORTUNATE RECENT INCIDENTS YOU ARE NOT ALLOWED TO INTERACT WITH YOUR CELL PHONE IN ANY WAY. IF YOU TOUCH YOUR CELL PHONE DURING THE EXAM YOU WILL GET A "0" NO MATTER WHAT YOU ARE DOING WITH THE PHONE. PUT IT AWAY AND LEAVE IT THERE!!!

Student Honor Code for the University of Texas at Austin

"I pledge, as a member of The University of Texas at Austin community, to do my work honestly, respectfully, and through the intentional pursuit of learning and scholarship."

Elaboration

1. I pledge to be honest about what I create and to acknowledge what I use that belongs to others.
2. I pledge to value the process of learning in addition to the outcome, while celebrating and learning from mistakes.
3. This code encompasses all of the academic and scholarly endeavors of the university community.

(Your signature)

PERIODIC TABLE OF THE ELEMENTS

Elementary Subatomic Particles																	
Symbol	Electron		Proton		Neutron		Photon		Restless								
Mass (kg)	$9.10938261 \times 10^{-31}$		$1.67262161 \times 10^{-27}$		$1.67492716 \times 10^{-27}$		0		0								
Relative mass (approx)	$5.48579909 \times 10^{-4}$		$1.00727647 \times 10^{-2}$		$1.00866491 \times 10^{-2}$		0		0								
Charge (Coulomb)	$-1.602176634 \times 10^{-19}$		$1.602176634 \times 10^{-19}$		0		0		0								
Spin quantum number	$1/2$		$1/2$		$1/2$		1		$1/2$								
<p>▼ % Ionic Character of a Single Chemical Bond</p> <p>Percent ionic character describes the nature of a bond. Bonds possessing 50% or greater ionic character are commonly termed ionic, bonds with less than 50% ionic character are termed covalent. Pauling's equation was modified by Henry</p> <p>Pauling's equation was modified by Henry</p> <p>Pauling's equation was modified by Henry</p>																	
<p>▼ Periodic Table of the Elements</p> <p>Atomic weight, atomic number, and other data are given for each element. The periodic table is arranged in order of increasing atomic number. The elements are grouped into periods and groups. The groups are labeled with Roman numerals I through VIII, and the subgroups are labeled with letters A and B. The noble gases are labeled with Roman numerals I through VIII, and the lanthanides and actinides are labeled with Roman numerals I through XIV.</p>																	

1. (4 points) What is the most important question in Organic Chemistry?

2. (6 points) I told you this would be here. The following amide molecule is 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. There is no need to draw any arrows on this one.



3. (12 points) Fill in each blank with the word that best completes the following sentences. This should look familiar as Rules of the Day.

The _____ density in molecules can be described mathematically by adding the _____ functions of all the _____ orbitals for all the atoms in the entire molecule, an approach referred to as _____ theory. This is the way we want you to think about _____ bonds, but it is not useful for students trying to understand _____ bonding in molecules.

The wave functions for the _____ orbitals on each atom can be added together (hybridized) first, before looking for overlap with orbitals from other atoms. This is called _____ theory and is the best way for students to think about _____ bonding in molecules as described by Linus Pauling.

3. (7 pts each) For the following molecular formula, draw complete Lewis line structures in which all atoms (even H atoms) are drawn, lines are used as bonds, all lone pairs are drawn AND ALL FORMAL CHARGES ARE INDICATED. Note you must infer the formal charges as we do not indicate them on the chemical formulas given



How many different stereoisomers are possible for the above molecule? _____



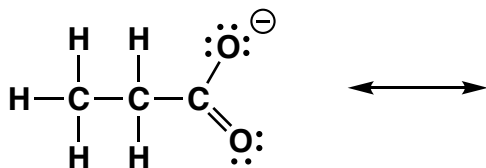
How many different stereoisomers are possible for the above molecule? _____



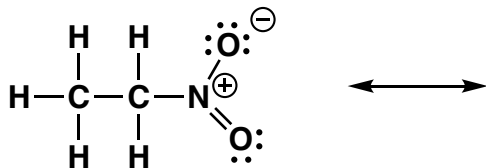
How many different stereoisomers are possible for the above molecule? _____

4. (21 pts) The following molecules are best represented as the hybrid of contributing structures. **Draw the other important contributing structure(s)** in the space(s) provided, including all lone pairs and formal charges. **For the structure(s) on the left, use arrows to indicate the movement of electrons to give the structure you drew.** No arrows for the structures on the right. Finally, if **one and only one** of the contributing structures makes a dominant (major) contribution to the resonance hybrid, **draw a circle around the dominant (major) contributor.** You might want to read these directions again to make sure you know what we want.

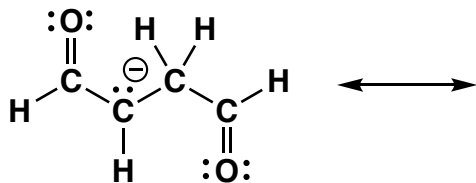
A.



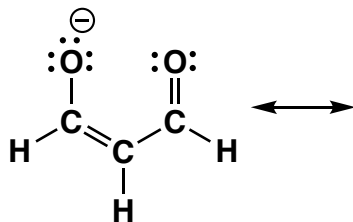
B.



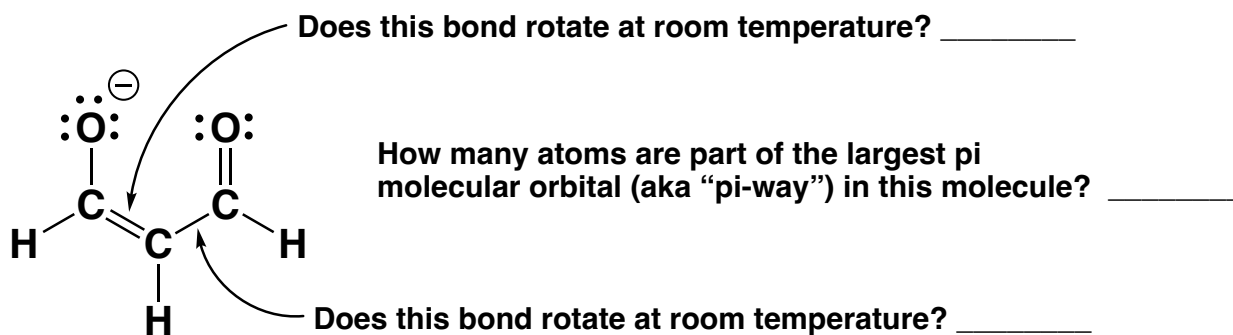
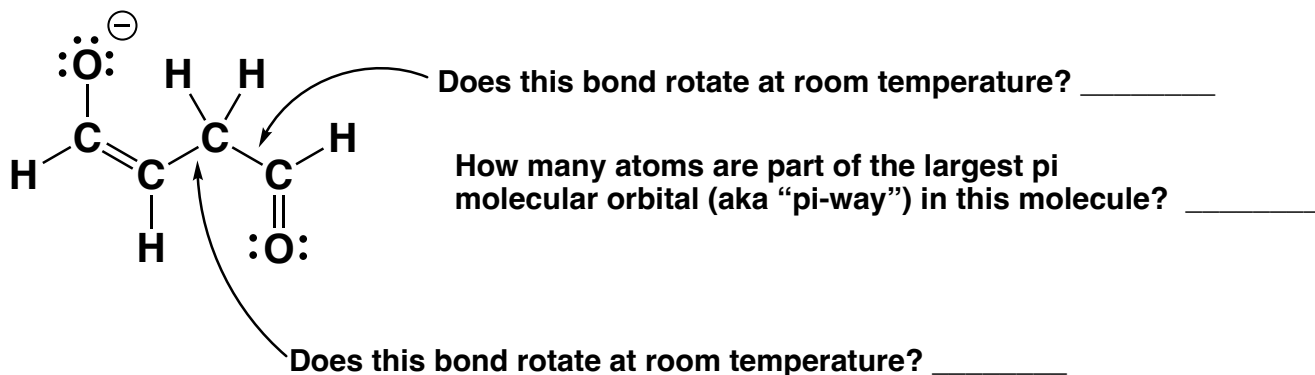
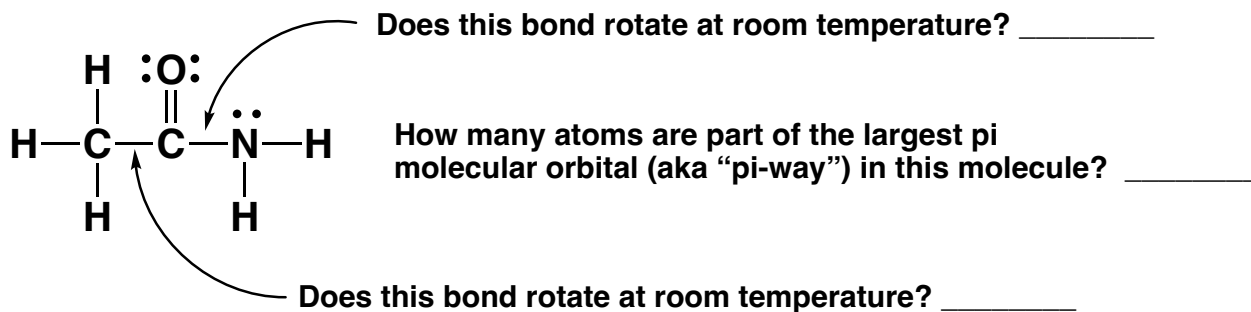
C.



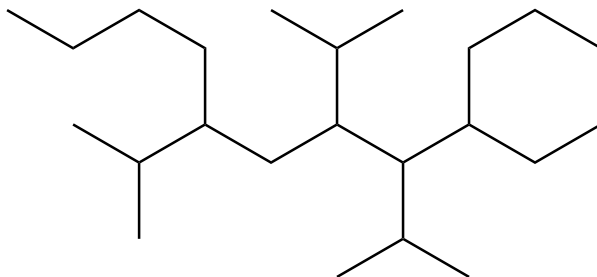
D.



5. (22 pts) Fill in each blank with either “yes” or “no” or provide a number as appropriate. **In addition, on all of the following structures, draw a small circle around all atoms that you would describe best as sp^2 hybridized.**



8. (8 pts) In the box below, provide an acceptable IUPAC name for the following molecule. Do not designate R or S for this.



Although stereochemistry is not indicated on the above structure, how many stereoisomers are possible? _____

9. (10 pts each) For the following IUPAC name, draw the appropriate line angle drawing. You can ignore R and S for this one.

5-(*sec*-Butyl)-3-ethyl-7-methylnonane

Although stereochemistry is not indicated on the above structure, how many stereoisomers are possible? _____

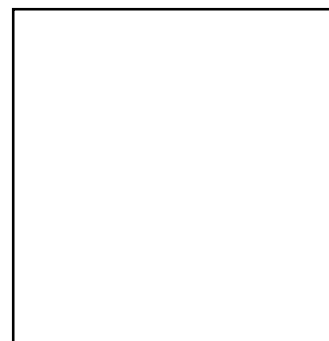
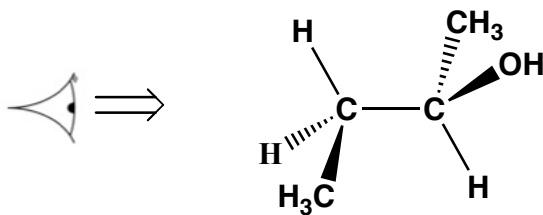
10. (10 pts each) For the following IUPAC name, draw the appropriate line angle drawing. For this one, you need to use wedges and dashes to indicate the appropriate stereochemistry at all chiral centers.

(4*R*,5*S*,8*S*)-4-ethyl-8-methyl-5-propylundecane



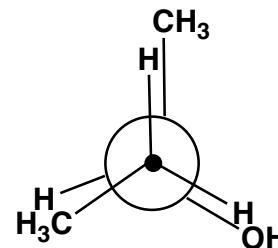
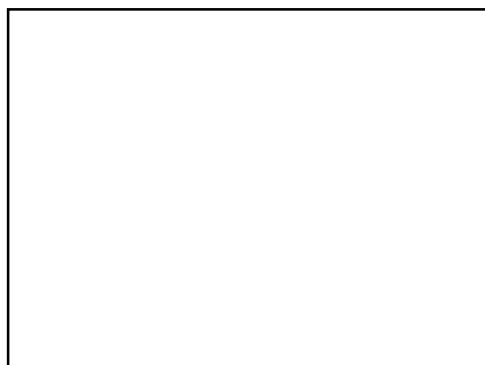
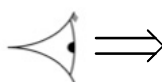
11. (4 pts) In the empty box, draw the Newman projection for the conformation of the following molecule.

A)



(7 pts) In the empty box draw a Lewis structure to indicate the conformation of the molecule indicated by the Newman projection shown. You will need to use wedges and dashes.

B)

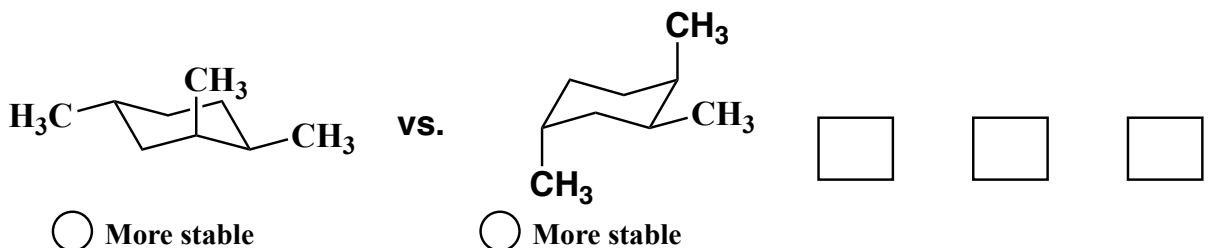
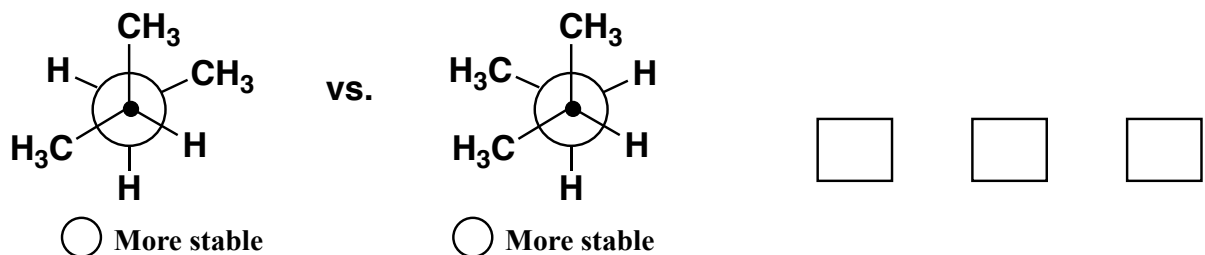
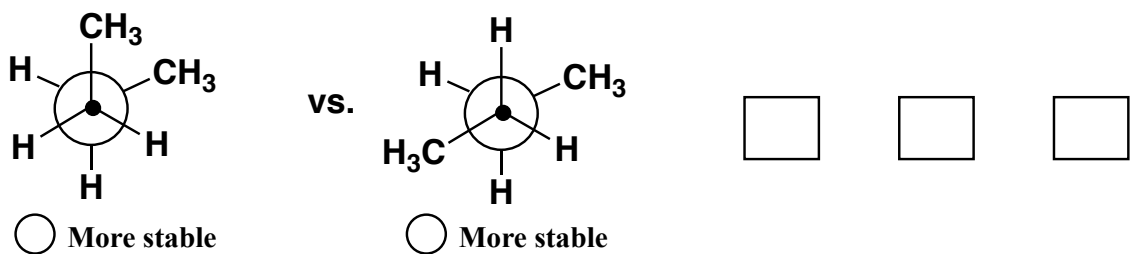
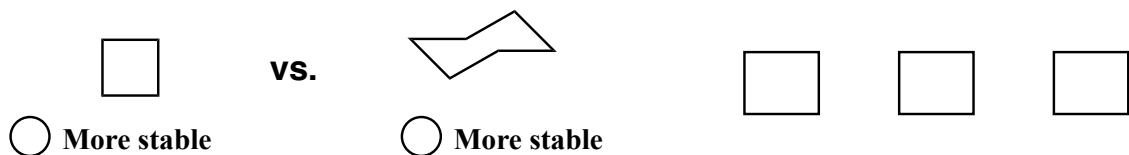
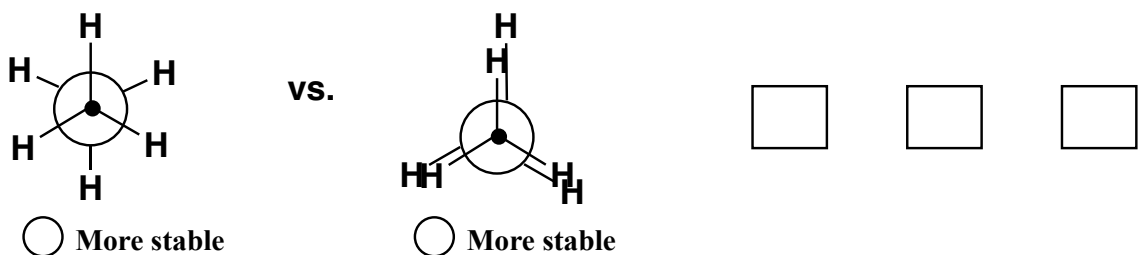
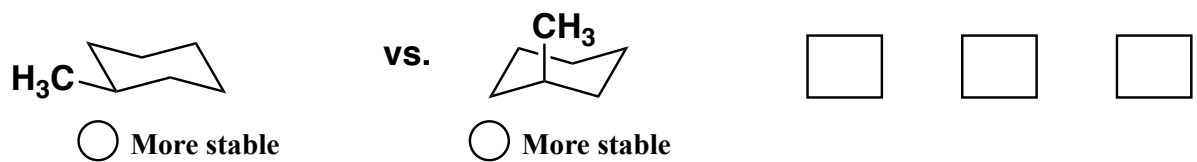


NOTICE THIS



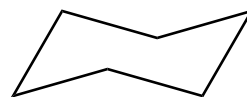
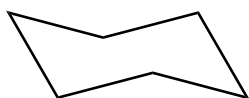
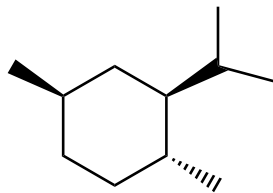
The same molecule was used in both parts of this problem. It is chiral, is it R or S? _____

12. (4 pts each) For each pair of molecules, fill in the circle under the one that is more stable of the two, then put an "X" in the box under all the types of strain that explain(s) your answer:



13. (22 pts) For the following cyclohexane derivatives, draw the two alternative chair conformations. IF there is a difference in stability, fill in the circle that says "More stable". If there is not any difference in stability, do not fill in any circle.

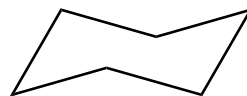
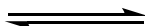
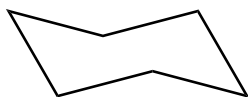
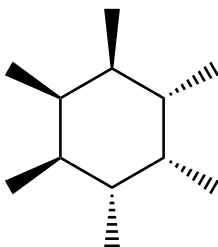
A)



More stable

More stable

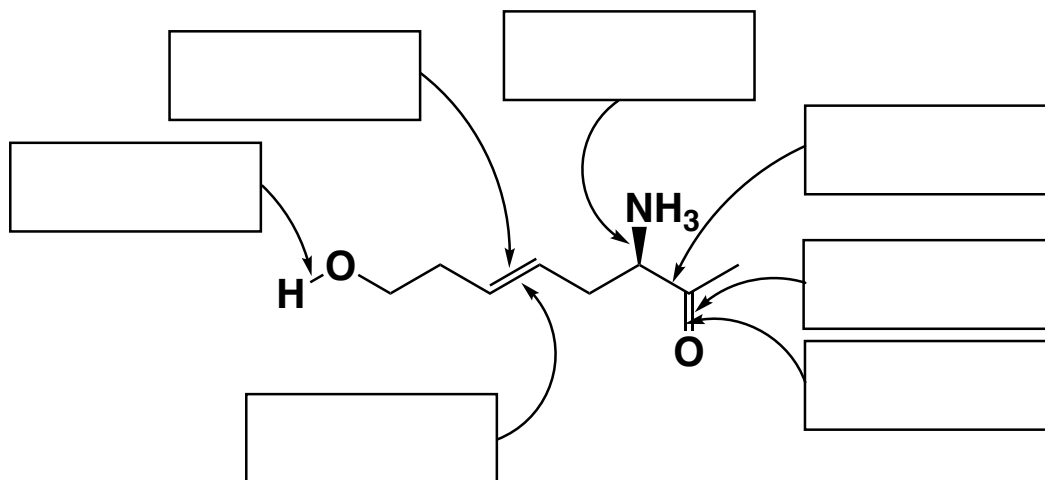
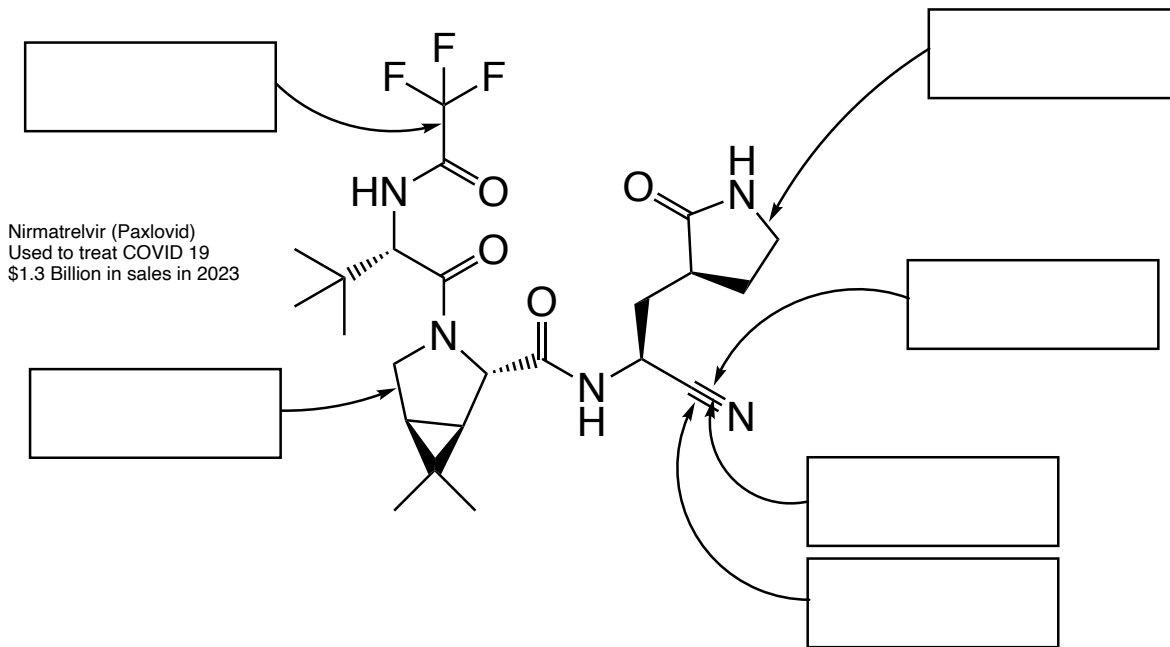
B)



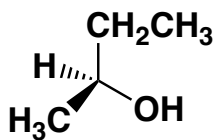
More stable

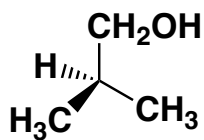
More stable

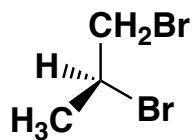
15. (2 pts each) Describe each bond indicated with an arrow as the overlap of orbitals. For example, an answer might be $\sigma_{Csp^3-Csp^3}$

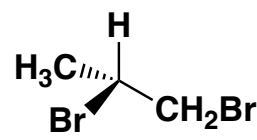


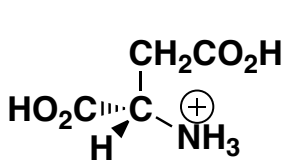
16. (2 pts each) Examine the following structures. For each molecule with a chiral center, assign the stereochemistry then write "R" or "S" as appropriate in the box provided below each structure. For all molecules that have no chiral centers, do not put anything in the box.

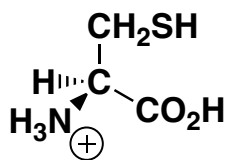


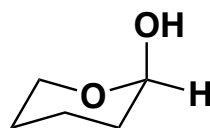


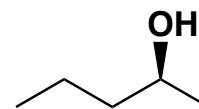




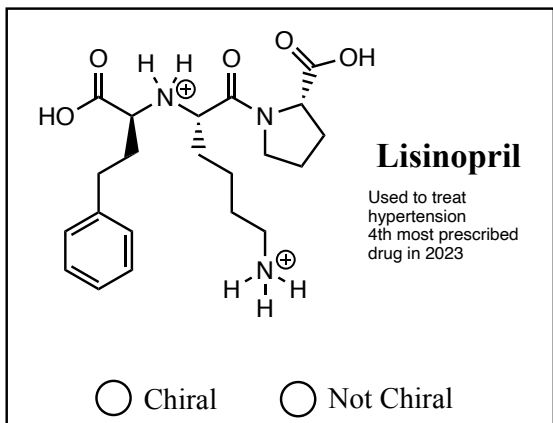
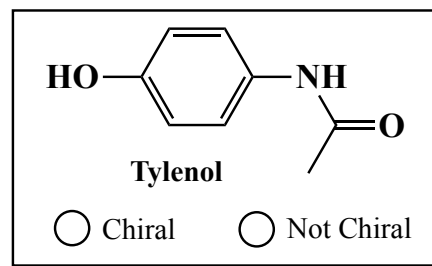
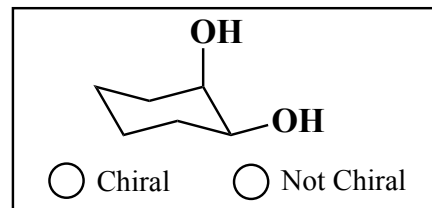
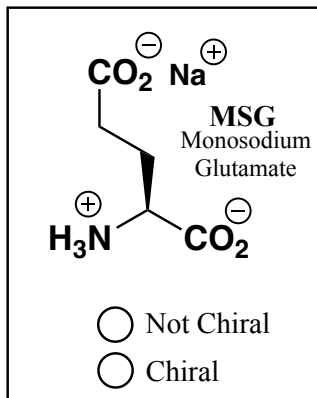
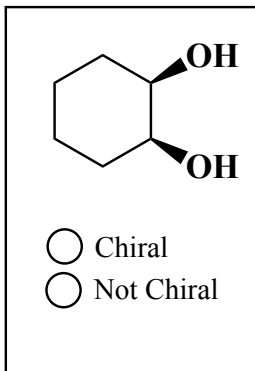
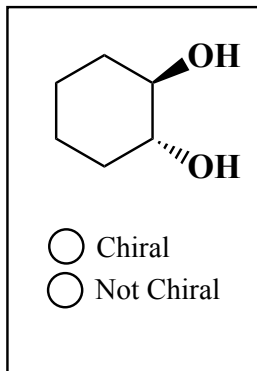








17. (15 pts) Fill in the appropriate circle to indicate whether the molecule is chiral or not chiral. Then answer the three questions at the bottom of the page.



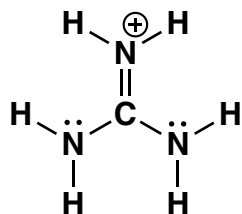
How many stereoisomers of Tylenol are possible?

How many stereoisomers of MSG are possible?

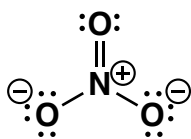
How many stereoisomers of Lisinopril are possible?

18. (26 points total). Here is an “apply what you know” problem in the form of an MCAT style passage.

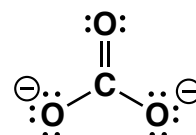
We have seen a number of molecules that contains a three-atom, delocalized pi bond (a “pi-way”). In particular, we have seen a carboxylate ion, enolate ion, and of course, amides. Each of the three atoms donates a 2p orbital that overlap. It is now time to consider molecules with 4 atoms. Below are organic ions that are common in biochemistry as well as organic chemistry.



Guanidinium cation
(important in biochemistry)

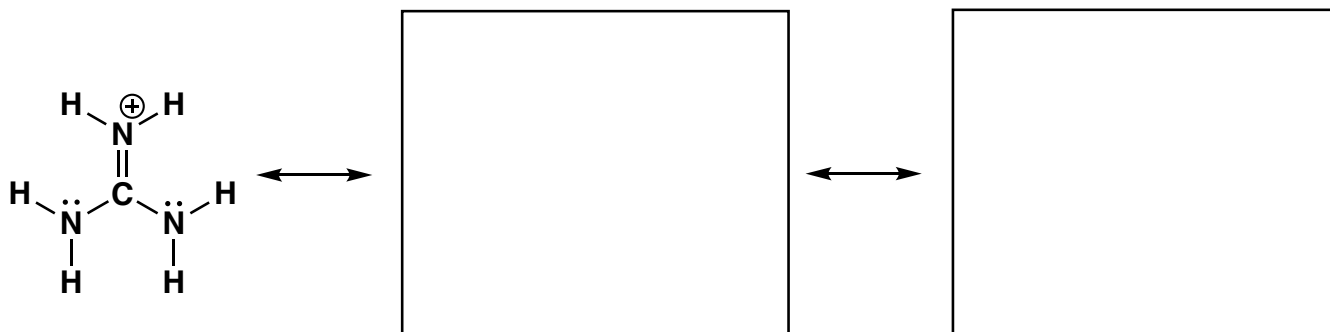


Nitrate anion



Carbonate dianion

- A) (8 pts) Draw the other two important contributing structures for the guanidinium cation and nitrate ion. As before, you must show all lone pairs and all formal charges. Use arrows for the two structures on the left to indicate how you are moving electrons to produce the structure immediately to the right. The structures on the right will have no arrows.



18. (cont).

The guanidinium cation is found on the side chain of the amino acid arginine. Arginine is important for establishing the overall charge in a protein, as well as interacting with other molecules through something called a cation-pi interaction. As you can tell from the contributing structures, no single Lewis structure can indicate the true situation for these ions.

B. (2 pts) For the guanidinium cation, what is the hybridization state of each nitrogen atom? Fill in the circle next to the correct answer.

- sp
- sp²
- sp³
- sp⁴

C. (2 pts) For the guanidinium cation, what is the hybridization state of the central carbon atom? Fill in the circle next to the correct answer.

- sp
- sp²
- sp³
- sp⁴

D. (2 pts) Given your answer to parts B and C, how many 2p orbitals are involved in the delocalized pi molecular orbitals for the guanidinium cation? Fill in the circle next to the correct answer.

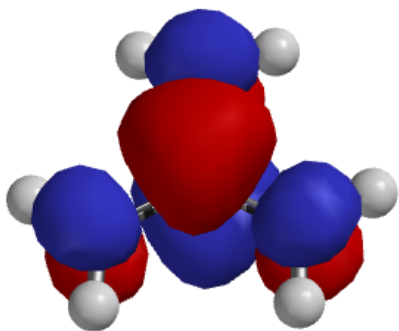
- 2
- 3
- 4
- 5

E. (2 pts) Given your answer to part D, how many pi molecular orbitals will be formed from the overlapping 2p orbitals? Fill in the circle next to the correct answer.

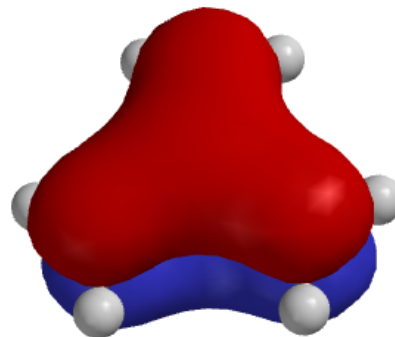
- 2
- 3
- 4
- 5

18. (cont).

- F. (4 pts) Below are the highest and lowest energy pi molecular orbitals for the guanidinium cation. Fill in the appropriate circles to indicate which orbital is the highest energy pi molecular orbital, and which is the lowest energy pi molecular orbital for the guanidinium cation. (Note, I have not shown any other pi molecular orbitals for the guanidinium cation here, just the highest and lowest energy ones)



- This is the lowest energy pi molecular orbital of the guanidinium cation.
- This is the highest energy pi molecular orbital of the guanidinium cation.



- This is the lowest energy pi molecular orbital of the guanidinium cation.
- This is the highest energy pi molecular orbital of the guanidinium cation.

- G. (2 pts) Do you expect the pi molecular orbitals to look substantially different for the guanidinium cation, nitrate anion and carbonate dianion?

- Yes, they will be substantially different.
- No, they will be very similar.

- H. (2 pts) One of the more difficult parts of the analysis of delocalized pi bonding concerns how many electrons are involved in the pi molecular orbitals. Each of the ions shown on page 13, the guanidinium cation, the nitrate anion, and the carbonate dianion, have the same number of pi electrons in the pi molecular orbitals. Fill in the circle for the answer that lists how many electrons reside in these pi molecular orbitals in the guanidinium cation, the nitrate anion, and the carbonate dianion?

- 2
- 4
- 6
- 8
- 10

18. (cont).

- I. (2 pts) Given your answer to part H, how many pi molecular orbitals are filled for the guanidium cation, the nitrate anion, and the carbonate dianion?

- 1
 2
 3
 4
 5

A good way to get ready for a 5K race is to remember that avoiding a running injury means being patient and increasing your distance slowly. Start by running as far as you can comfortably. Do not push it at the beginning. Let's say you can run 1 mile before feeling too out of breath. Run that 1 mile 2-3 times a week at first, making sure you have no foot or leg pain. If you do have foot/leg issues, try new running shoes fit by a professional (The Loop or Rogue Running are great running stores for this). After you are comfortable running 1 mile for a week, try 1.25 miles for 2-3 times the next week. Then run to 1.5 miles, then 2.0 miles, then 2.5 miles each 2-3 times for a week. It will then be time for the race and you will make it the full 3.1 miles!!!