NAME (Print): _____

EID _____

SIGNATURE: _____

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

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

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 INCIDENCTS 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!!!

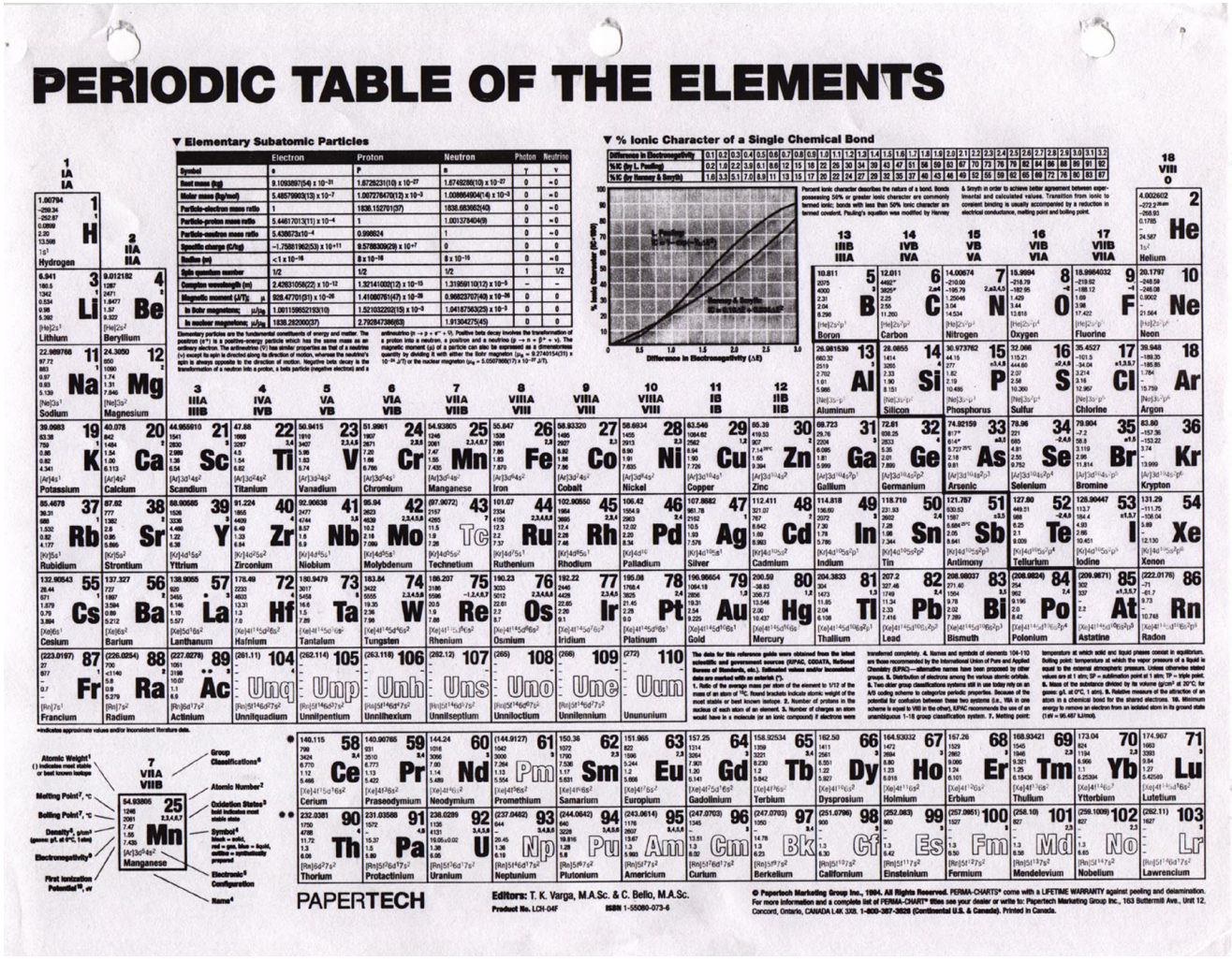
Student Honor Code for the University of Texas at Austin

"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)

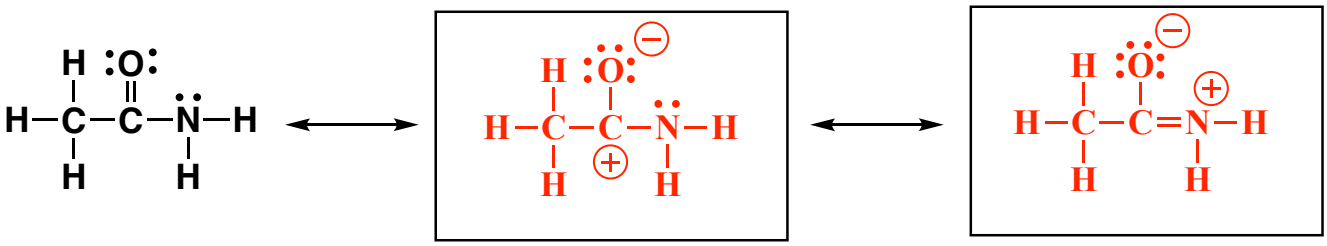


Signature_____ Pg 1 _____(22)

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

Where are the electrons?

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.



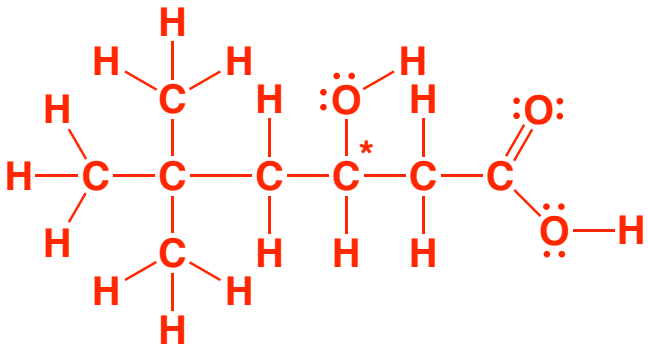
3. (12 points) Fill in each blank with the word that best completes the following sentences. This should look familiar as Rules of the Day.

The _____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 refered to as _____molecular_____ _____orbital_____ theory. This is the way we want you to think about _____pi_____ bonds, but it is not useful for students trying to understand _____sigma_____bonding in molecules.

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

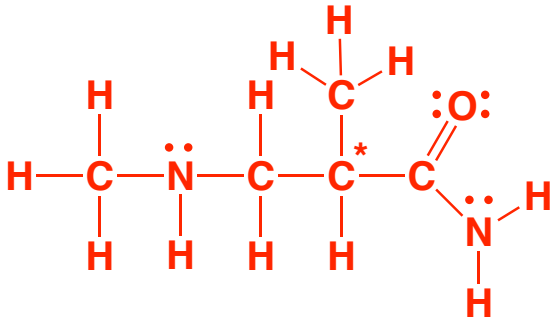
3. (7 pts each) For the following molecular formula, draw complete Lewis line structures in which all atoms (even H atoms) are drawn, lines are used as bonds, all lone pairs are drawn AND ALL FORMAL CHARGES ARE INDICATED. Note you must infer the formal charges as we do not indicate them on the chemical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

1) **$(CH_3)_3CCH_2CHOHCH_2CO_2H$**



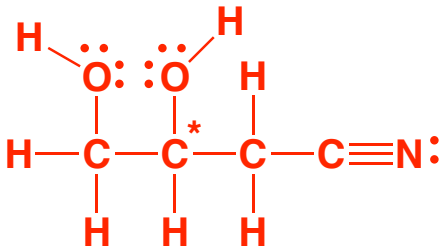
How many different stereoisomers are possible for the above molecule? 2

2) **$CH_3NHCH_2CH(CH_3)CH_2CONH_2$**



How many different stereoisomers are possible for the above molecule? 2

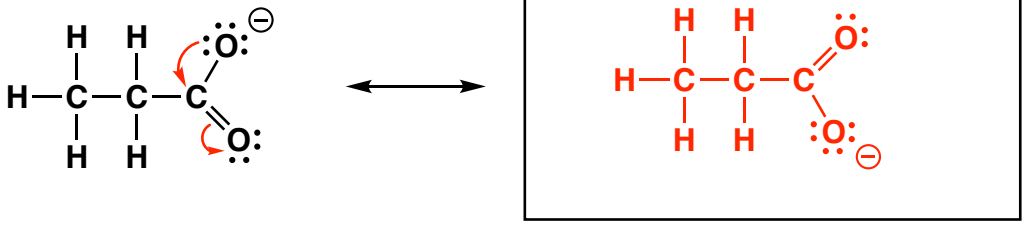
3) **$CH_2OHCHOHCH_2CN$**



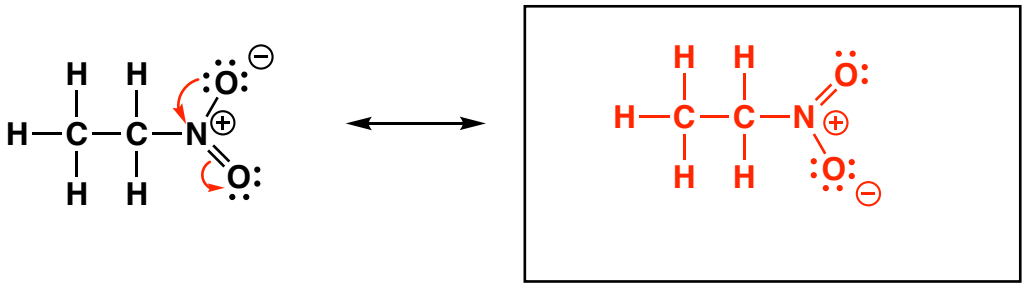
How many different stereoisomers are possible for the above molecule? 2

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.

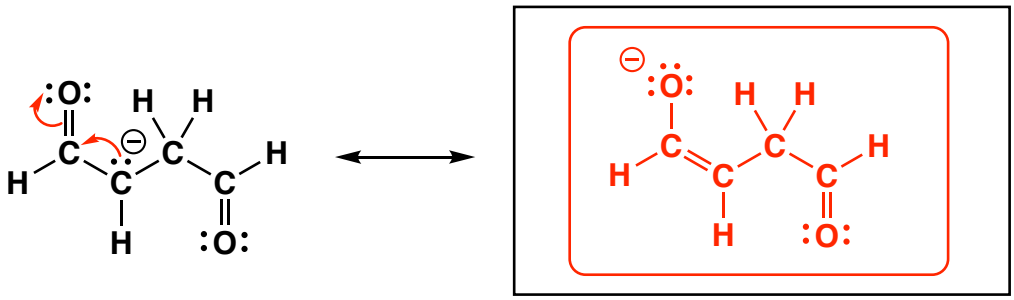
A.



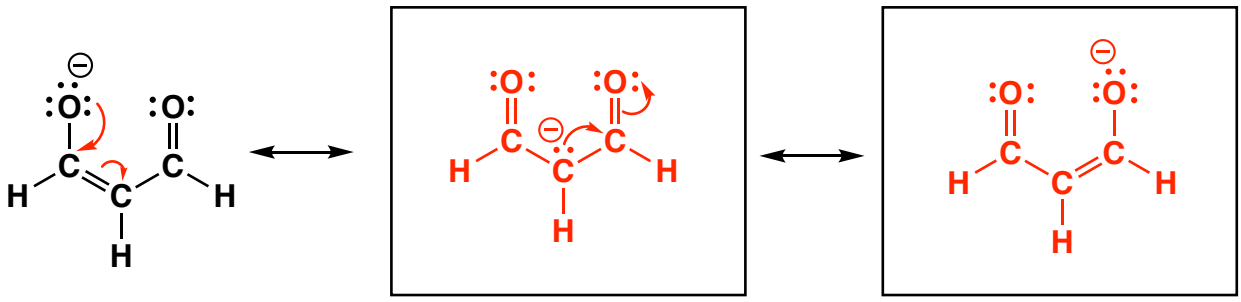
B.



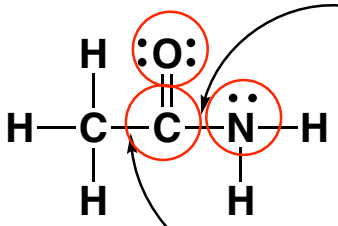
C.



D.



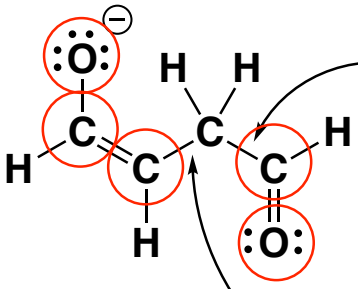
5. (22 pts) Fill in each blank with either "yes" or "no" or provide a number as appropriate. **In addition, on all of the following structures, draw a small circle around all atoms that you would describe best as sp^2 hybridized.**



Does this bond rotate at room temperature? No

How many atoms are part of the largest pi molecular orbital (aka "pi-way") in this molecule? 3

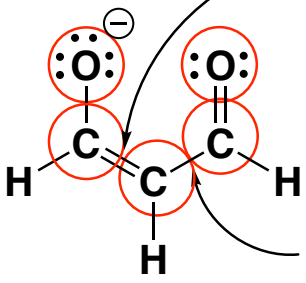
Does this bond rotate at room temperature? Yes



Does this bond rotate at room temperature? Yes

How many atoms are part of the largest pi molecular orbital (aka "pi-way") in this molecule? 3

Does this bond rotate at room temperature? Yes

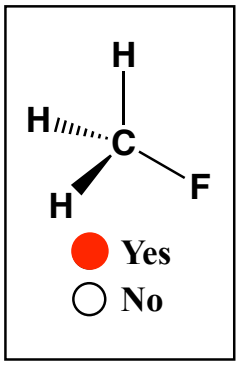


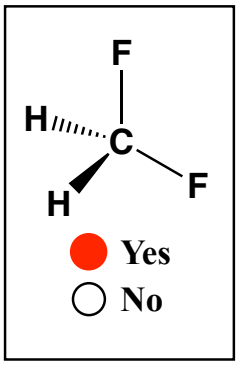
Does this bond rotate at room temperature? No

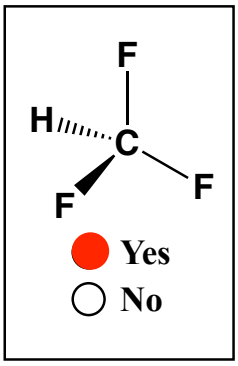
How many atoms are part of the largest pi molecular orbital (aka "pi-way") in this molecule? 5

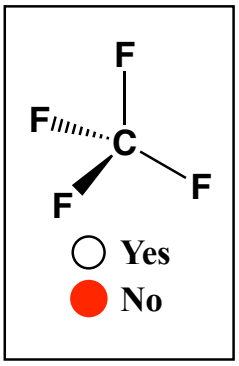
Does this bond rotate at room temperature? No

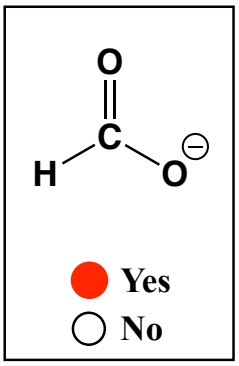
6. (18 pts) Indicate which of the following molecules have an overall molecular dipole moment. You do not need to indicate the direction of the dipole moment, or any of the individual bond dipoles. Fill in the circle next to "Yes" if the molecule has an overall molecular dipole, or "No" if the molecule does not have an overall molecular dipole moment.

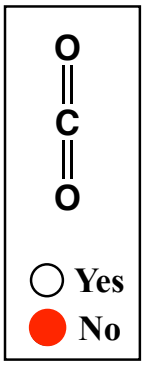


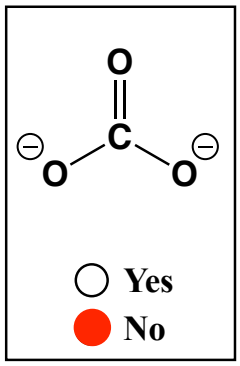


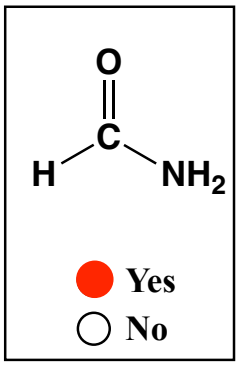


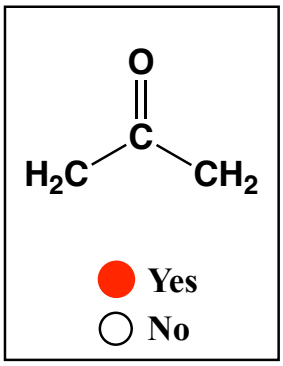




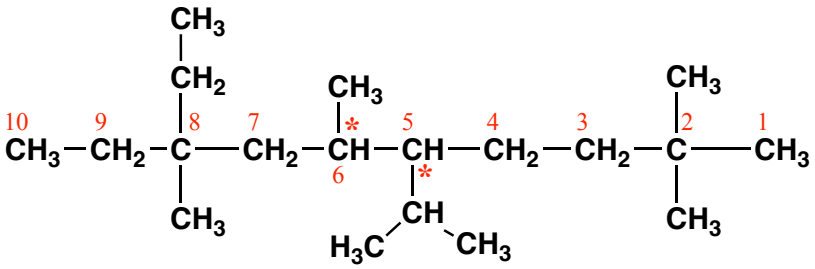








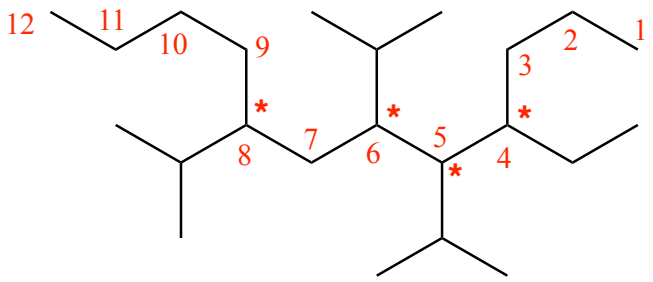
7. (8 pts) In the box below, provide an acceptable IUPAC name for the following molecule. Do not designate R or S for this.



8-ethyl-5-isopropyl-2,2,6,8-tetramethyldecane
or 8-ethyl-2,2,6,8-tetramethyl-5-(1-methylethyl)decane

Although stereochemistry is not indicated on the above structure, how many stereoisomers are possible? $2^2 = 4$

8. (8 pts) Provide an acceptable IUPAC name for the following molecule. Do not designate R or S for this.

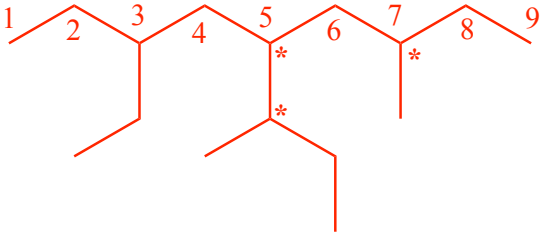


4-ethyl-5,6,8-triisopropyldodecane
or 4-ethyl-5,6,8-tri(1-methylethyl)dodecane

Although stereochemistry is not indicated on the above structure, how many stereoisomers are possible? $2^4 = 16$

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

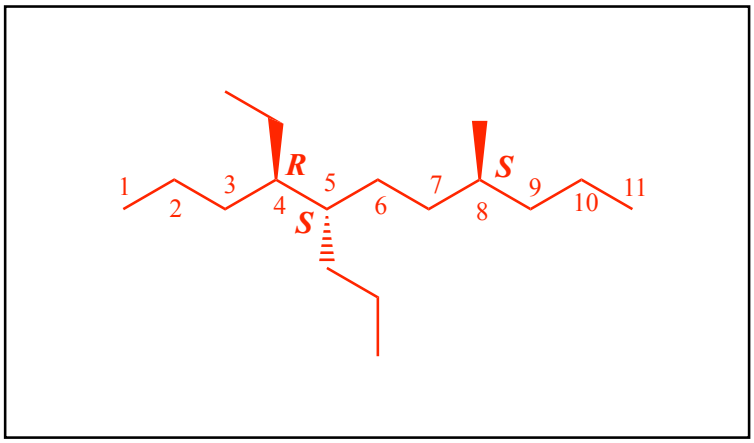
5-(*sec*-Butyl)-3-ethyl-7-methylnonane



Although stereochemistry is not indicated on the above structure, how many stereoisomers are possible? $2^3 = 8$

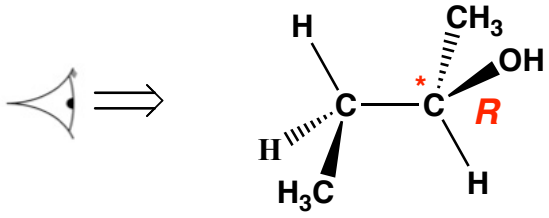
10. (10 pts each) For the following IUPAC name, draw the appropriate line angle drawing. For this one, you need to use wedges and dashes to indicate the appropriate stereochemistry at all chiral centers.

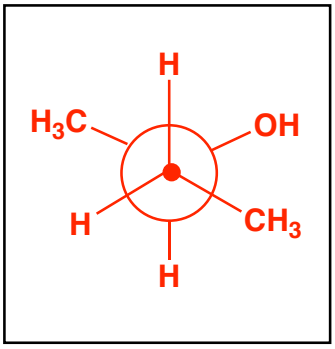
(4*R*,5*S*,8*S*)-4-ethyl-8-methyl-5-propylundecane



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

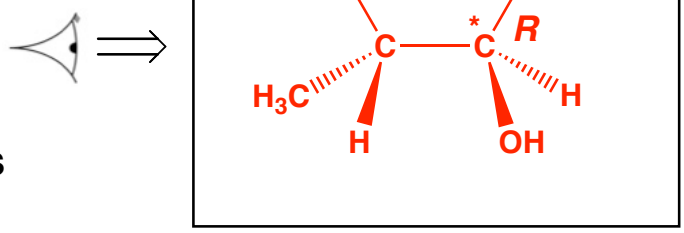
A)

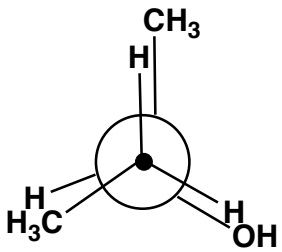




(7 pts) In the empty box draw the conformation of the molecule indicated by the Newman projection shown.

B)

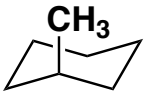
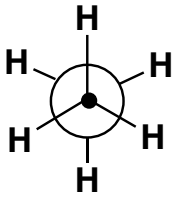
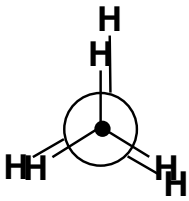
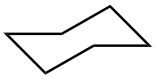
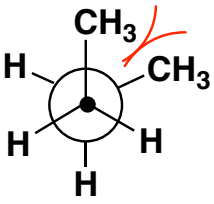
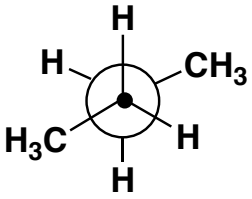
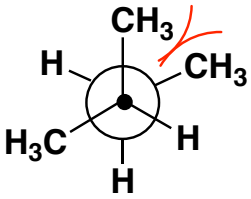
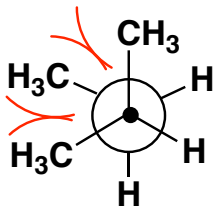
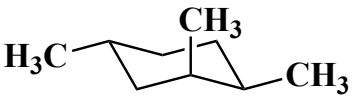
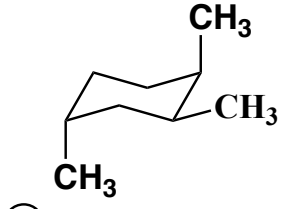




NOTICE THIS

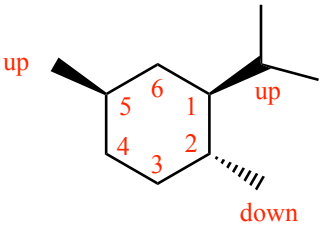
The same molecule was used in both parts of this problem. It is chiral, is it R or S? *R*

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:

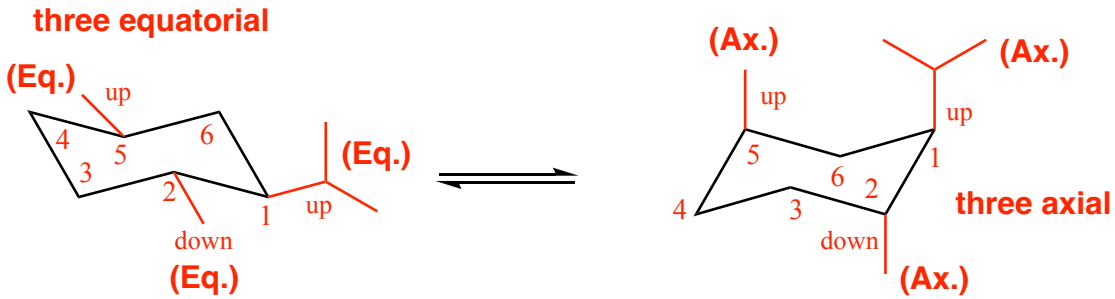
			Angle strain	Torsional strain	Steric strain
 ● More stable	vs.	 ○ More stable	☐	☐	X
 ● More stable	vs.	 ○ More stable	☐	X	☐
☐ ○ More stable	vs.	 ● More stable	X	X	☐
 ○ More stable	vs.	 ● More stable	☐	☐	X
 ● More stable	vs.	 ○ More stable	☐	☐	X
 ● More stable	vs.	 ○ More stable	☐	☐	X

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.

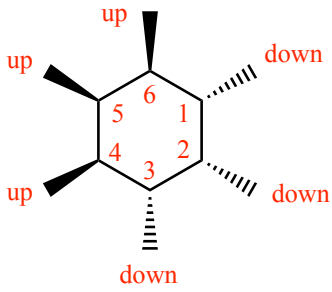
A)



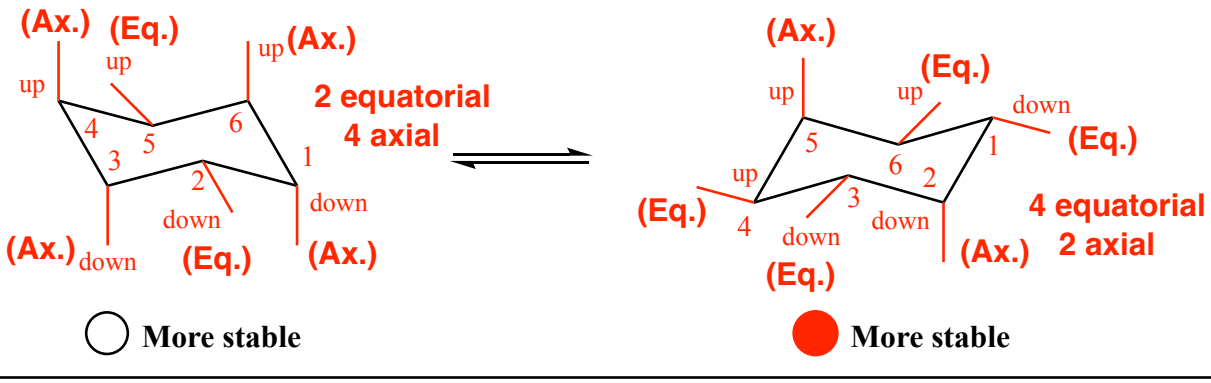
It is critical that you number in the same direction on all structures, I numbered clockwise here



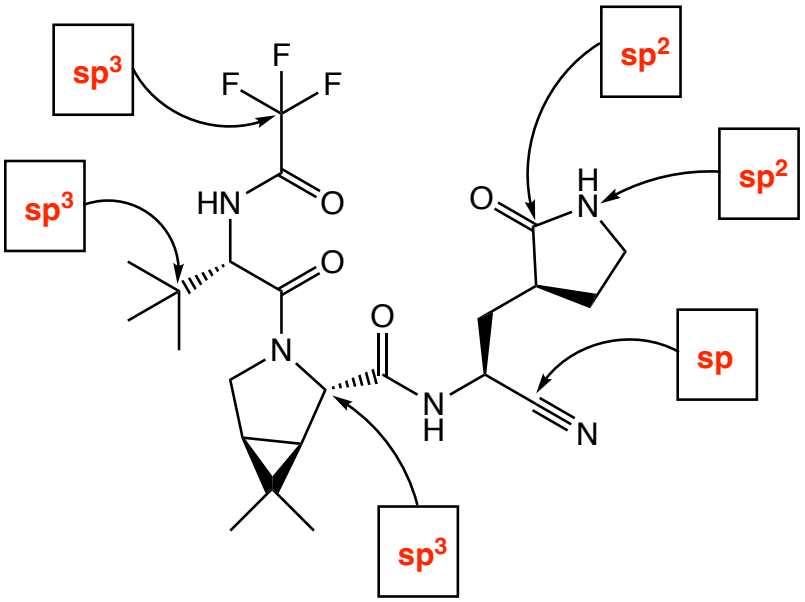
B)



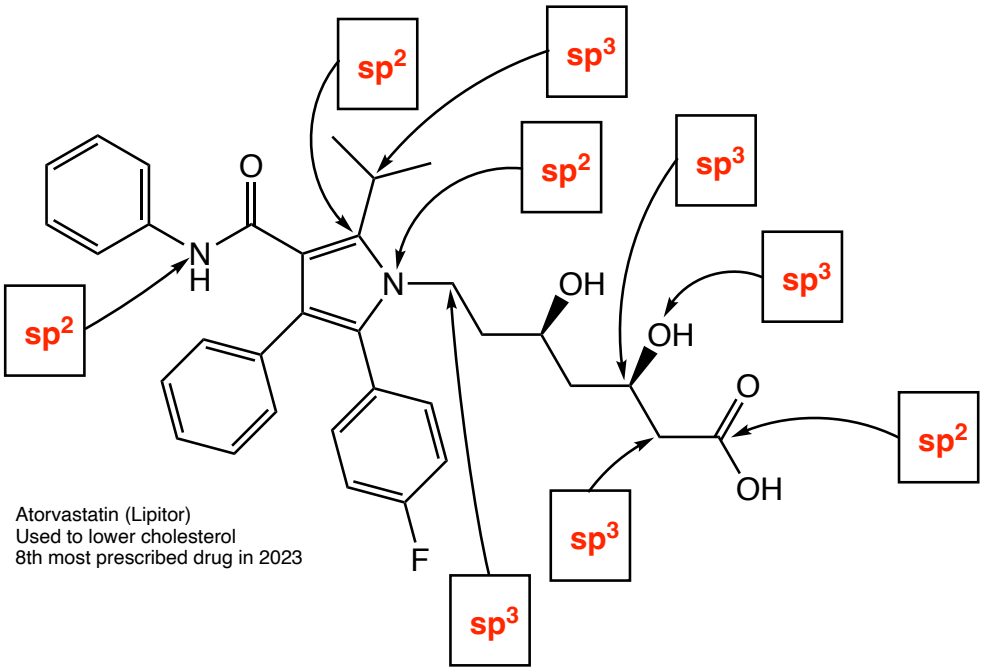
It is critical that you number in the same direction on all structures, I numbered clockwise here



14. (1 pt each) In the boxes provided, write the hybridization state of the atoms indicated by the arrow.

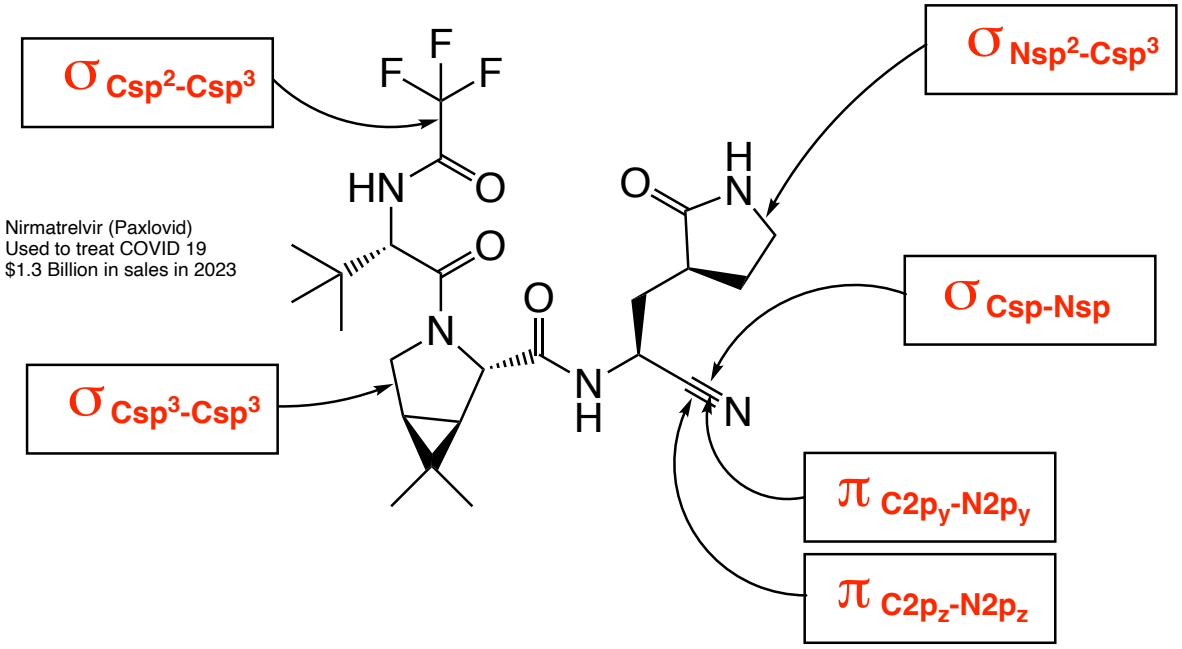


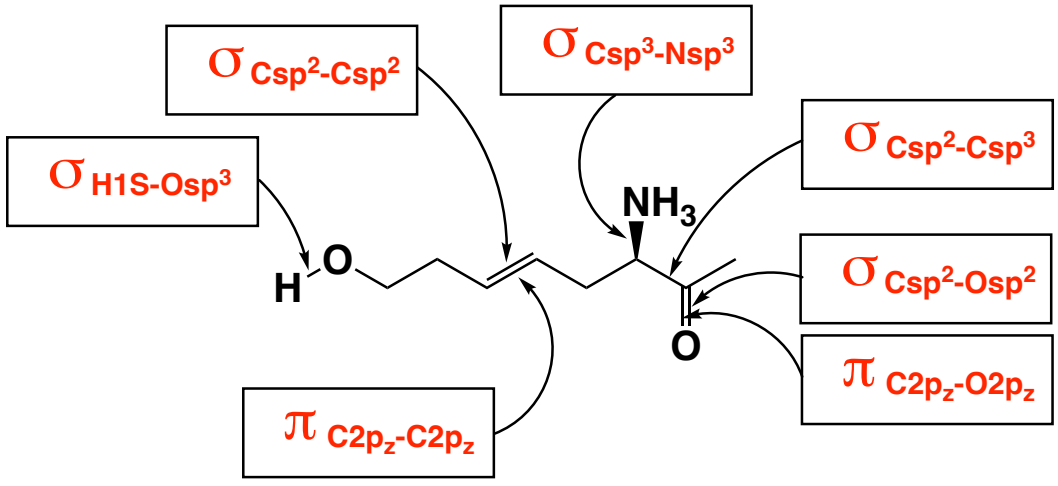
Nirmatrelvir (Paxlovid)
Used to treat COVID 19
$1.3 Billion in sales in 2023



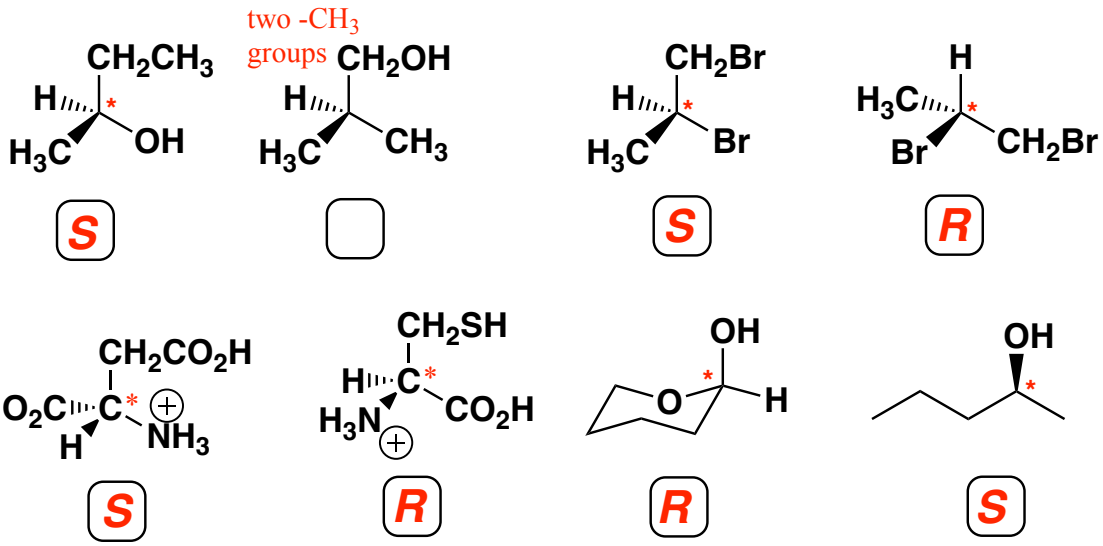
Atorvastatin (Lipitor)
Used to lower cholesterol
8th most prescribed drug in 2023

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

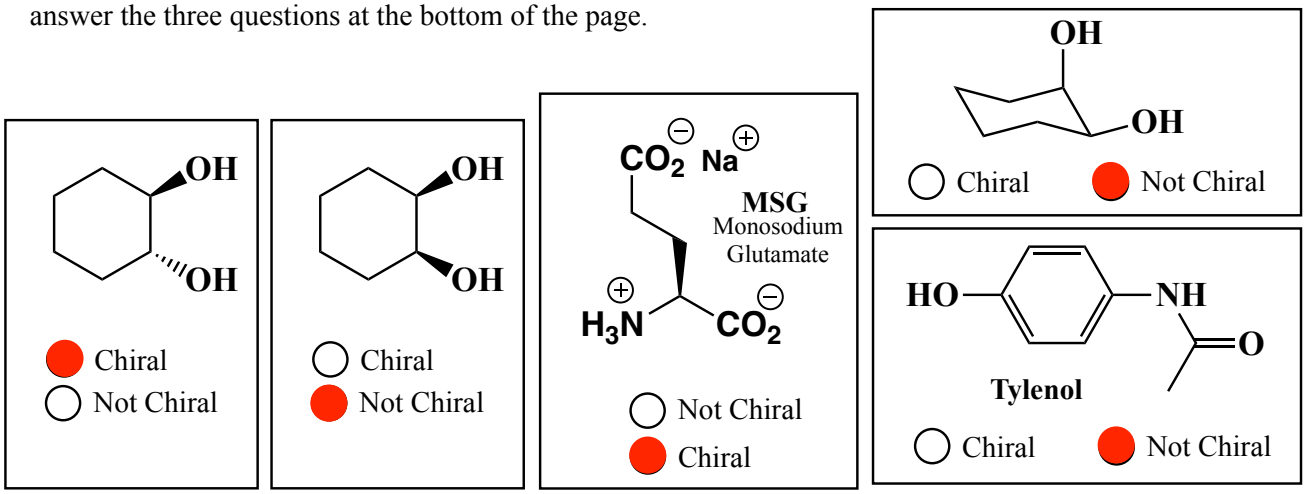


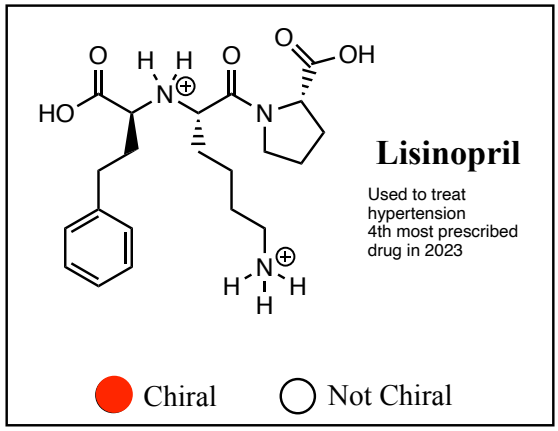


16. (2 pts each) Examine the following structures. For each molecule with a chiral center, assign the stereochemistry then write "R" or "S" as appropriate in the box provided below each structure. For all molecules that have no chiral centers, do not put anything in the box.



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.





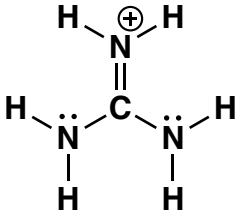
How many stereoisomers of Tylenol are possible? **1**

How many stereoisomers of MSG are possible? **2**

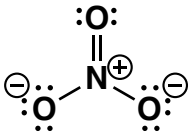
How many stereoisomers of Lisinopril are possible? **8**

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

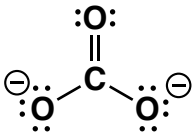
We have seen a number of molecules that contains a three-atom, delocalized pi bond (a "pi-way"). In particular, we have seen a carboxylate ion, enolate ion, and of course, amides. Each of the three atoms donates a 2p orbital that overlap. It is now time to consider molecules with 4 atoms. Below are organic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



Guanidinium cation
(important in biochemistry)

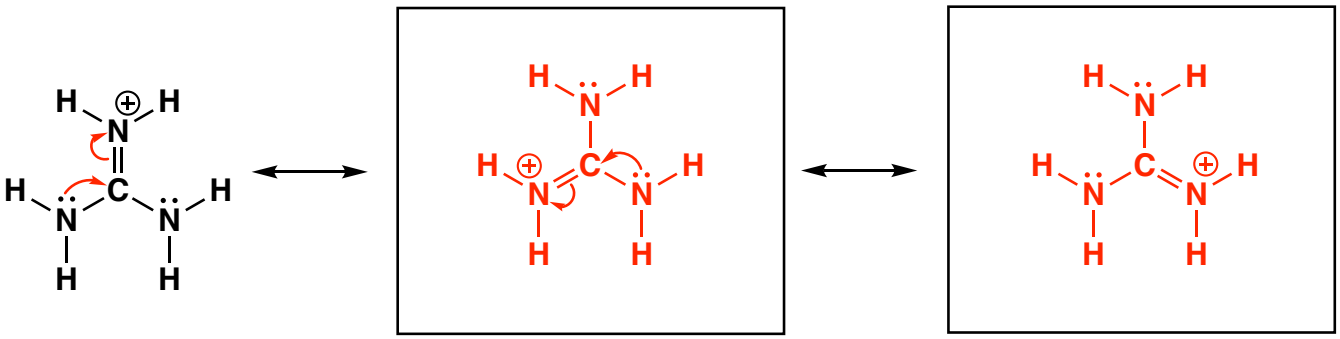


Nitrate anion



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 guanidium 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
- ● sp^2
- ○ sp3
- ○ sp^4

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
- ● sp^2
- ○ sp3
- ○ sp^4

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.

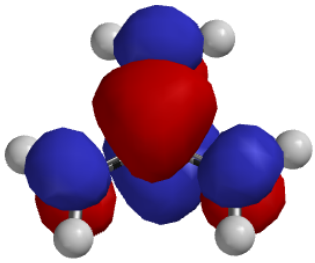
- ○ 2
- ○ 3
- ● 4
- ○ 5

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

- ○ 2
- ○ 3
- ● 4
- ○ 5

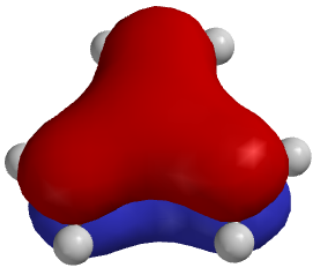
18. (cont).

F. (4 pts) Below are the highest and lowest energy pi molecular obitals for the guanidinium cation. Fill in the appropiate 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 enegy 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 substanially 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 guanidium 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 guanidium 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!!!