NAME (Print): _____

EID _____

SIGNATURE: _____

Chemistry 320M/328M
Dr. Brent Iverson
1st Midterm
September 26, 2019

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

Please Note: This test may be a bit long, but there is a reason. I would like to give you a lot of little questions, so you can find ones you can answer and show me what you know, rather than just a few questions that may be testing the one thing you forgot. **I recommend you look the exam over and answer the questions you are sure of first**, then go back and try to figure out the rest. Also make sure to **look at the point totals** on the questions as a guide to help budget your time.

You cannot use a red pen to take the exam. You must have your answers written in PERMANENT ink if you want a regrade!!!! This means no test written in pencil or ERASABLE INK will be regraded.

Please note: We routinely photocopy a number of exams following initial grading to guard against receiving altered answers during the regrading process.

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!!!

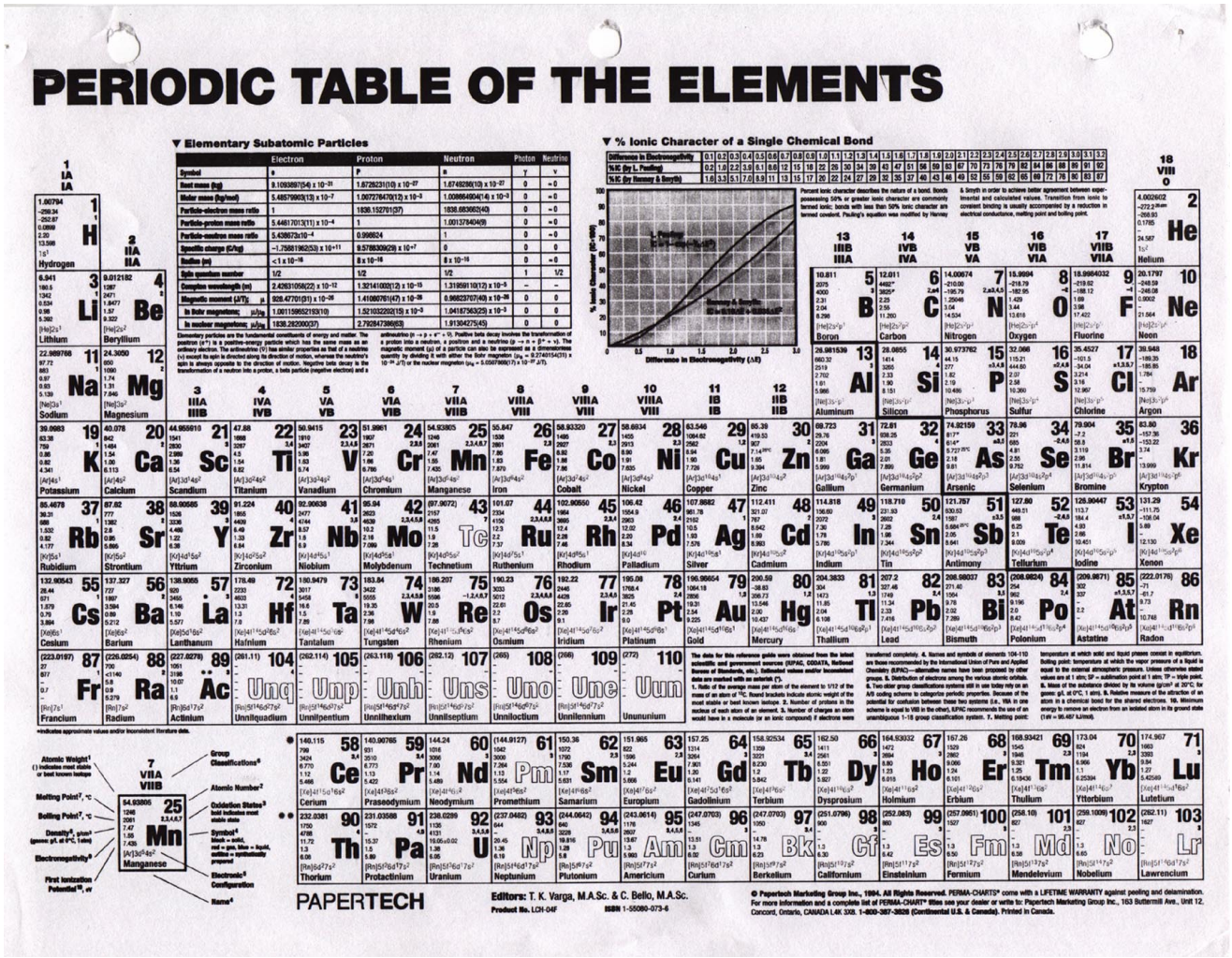
Page	Points	
1		(28)
2		(21)
3		(29)
4		(26)
5		(32)
6		(21)
7		(20)
8		(21)
9		(26)
10		(20)
11		(24)
12		(26)
13		(18)
14		(37)
15		(4)
16		(16)
Total		(369)

Student Honor Code

“As a student of The University of Texas at Austin, I shall abide by the core values of the University and uphold academic integrity.”

_____

(Your signature)



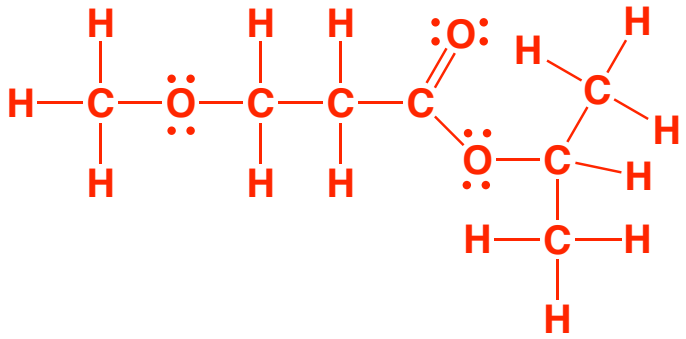
Signature_____ Pg 1 _____(28)

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

Where are the electrons?

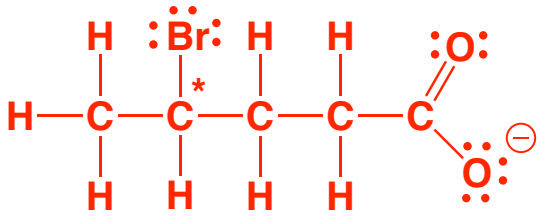
2. (8 pts each) For the following molecular formula, draw complete Lewis line structures in which all atoms (even H atoms) are drawn, lines are used as bonds, all lone pairs are drawn AND ALL FORMAL CHARGES ARE INDICATED. Note you must infer the formal charges as we do not indicate them on the chemical formulas given

1) $CH_3OCH_2CH_2CO_2CH(CH_3)_2$



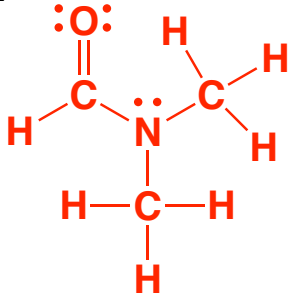
How many different stereoisomers are possible for the above molecule? 1

2) $CH_3CHBrCH_2CH_2CO_2$



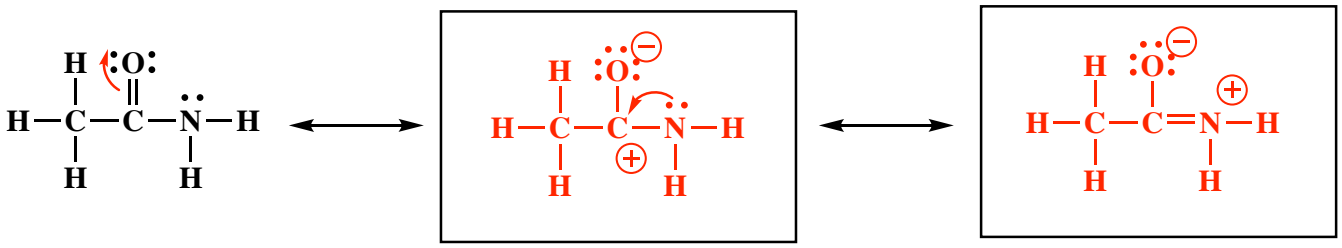
How many different stereoisomers are possible for the above molecule? 2

3) $HCON(CH_3)_2$



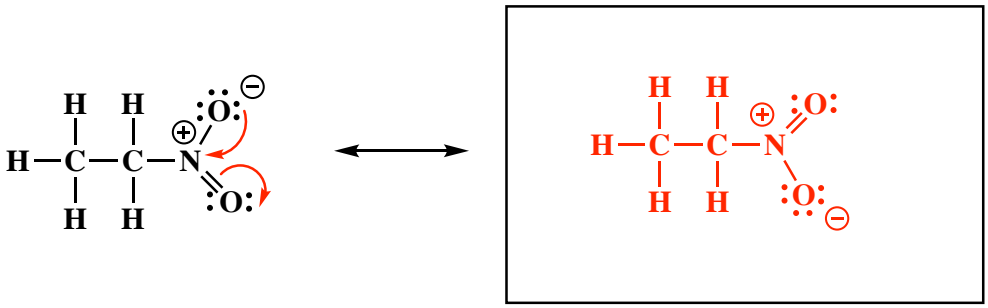
How many different stereoisomers are possible for the above molecule? 1

3. (10 pts) 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. **For the two structures on the left use arrows to indicate the movement of electrons to give the structures you drew.** There is **no need to draw any circles around any of these contributing strucures**. You might want to read these directions again to make sure you know what we want.

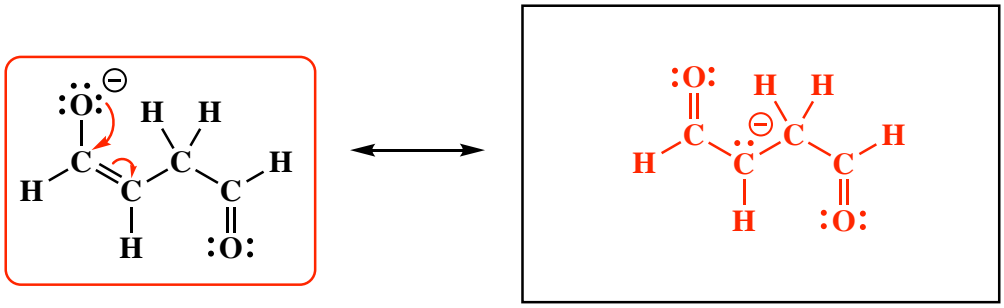


4. (11 pts) The following molecules are best represented as the hybrid of contributing structures. **Draw the second important contributing structure** in the space provided, including all lone pairs and formal charges. **For the structure on the left, use arrows to indicate the movement of electrons to give the structure you drew.** Finally, if one of the two 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.

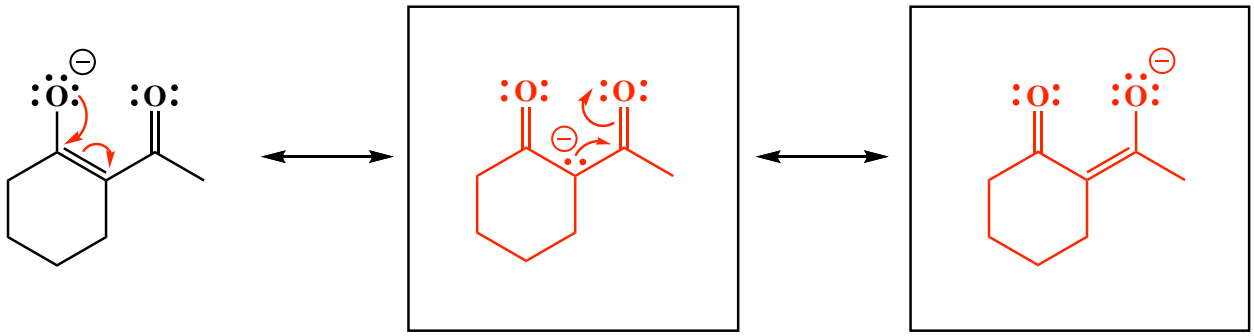
A.



B.

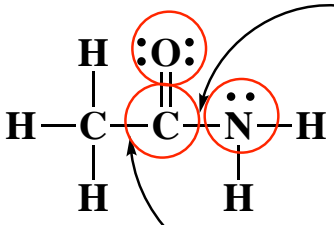


5. (10 pts) The following molecule is best represented as the hybrid of three contributing structures. **Draw the second and third important contributing structures** in the spaces provided, including all lone pairs and formal charges. **For the two structures on the left, use arrows to indicate the movement of electrons to give the structures you drew.** There is **no need to draw any circles around any of these contributing strucures**. You might want to read these directions again to make sure you know what we want.



Note that having a third important contributing structure provides extra stability to this anion. That will be important for the last problem (the MCAT style passage)

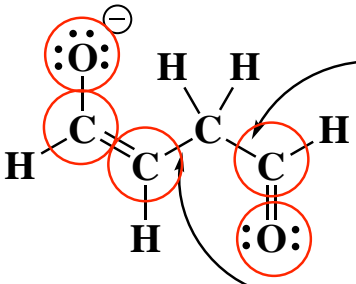
6. (19 pts) Fill in the blank with either "yes" or "no" as appropriate. **In addition, on all of the following structures, draw a small circle around all atoms that you would describe best as sp^2 hybridized.**



Does this bond rotate at room temperature? **No**

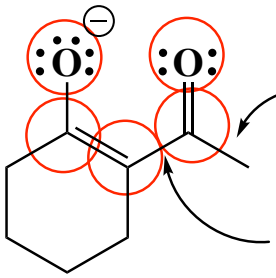
Remember that all the atoms of the pi way must contribute a 2p orbital, so they all must be sp^2

Does this bond rotate at room temperature? **Yes**



Does this bond rotate at room temperature? **Yes**

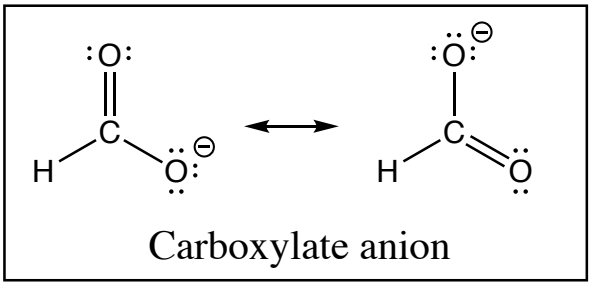
Does this bond rotate at room temperature? **Yes**



Does this bond rotate at room temperature? **Yes**

Does this bond rotate at room temperature? **No**

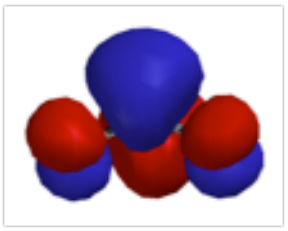
7. (26 pts) The following paragraph refers the carboxylate anion and you may recognize it from a handout we provided in class. Fill in each blank with the word or number that best completes the sentences.

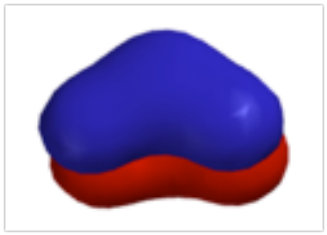


Carboxylate anion

A common situation, and the one many resonance ___contributing___ structures describe, occurs when three ___2p___ orbitals combine on adjacent atoms. A good example is the carboxylate anion. When three adjacent ___2p___ orbitals interact (we add the three orbital ___wave___ functions), three new ___molecular___ orbitals are produced; a low energy ___bonding___ "pi-way" orbital, a ___non-bonding___ orbital of intermediate energy and a high energy ___antibonding___ orbital. This pattern of three orbitals is generally the same whenever three ___2p___ orbitals interact even if there are different atoms involved, for example the enolate ion or allyl cation. There are ___four___ (a number) electrons in the pi system of the carboxylate anion, (you can see this by looking at either of the contributing structures; ___two___ (a number) electrons from the pi bond and ___two___ (a number) electrons from the third lone pair on the negatively charge O atom. Note the electron density on only the O atoms of the ___non-bonding___ orbital explains why the negative charge is localized on the O atoms in the carboxylate anion.

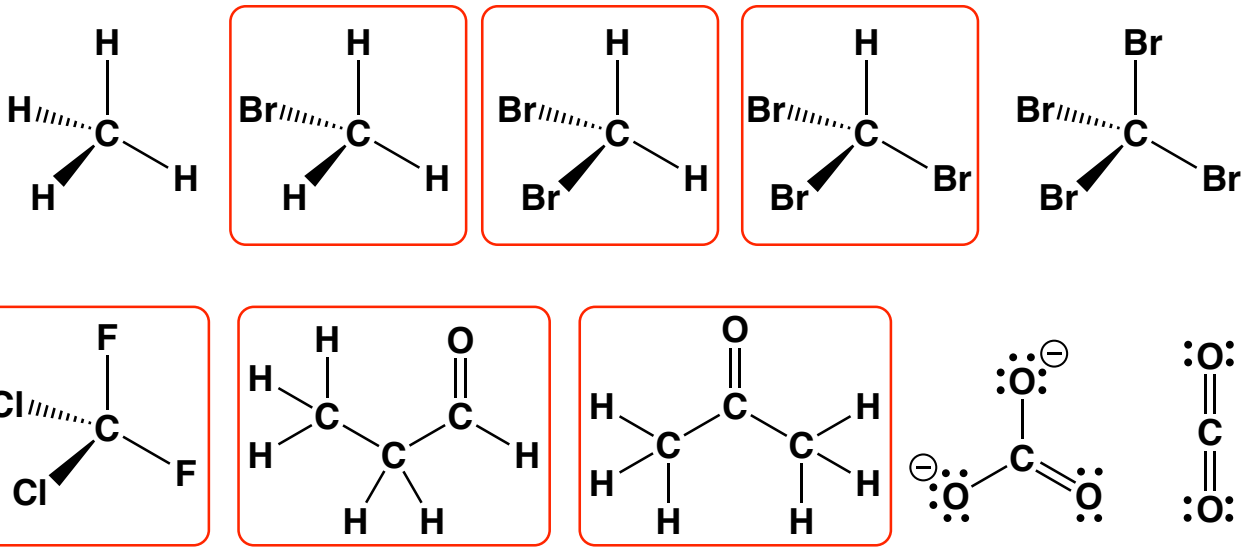
8. (12 pts) The following paragraph refers to the carboxylate anion from the previous page. These orbitals should be familiar to you. Under each, place all the words or phrases from the following list that apply to that particular orbital: **bonding, non-bonding, antibonding, filled, unfilled, lowest in energy, of intermediate energy, highest in energy, pi molecular orbital, sigma molecular orbital.** Note that all twelve blanks should be filled.





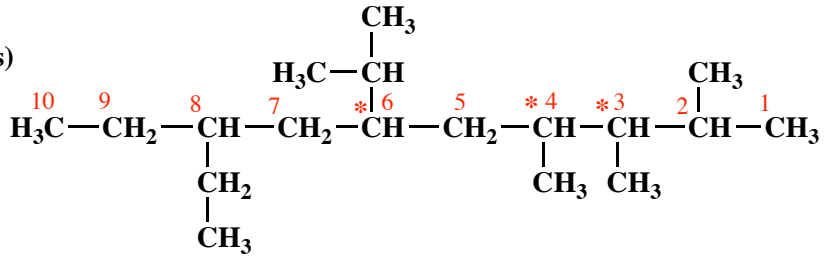
non-bonding	**antibonding**	**bonding**
filled	**unfilled**	**filled**
of intermediate energy	**highest in energy**	**lowest in energy**
pi molecular orbital	**pi molecular orbital**	**pi molecular orbital**

9. (20 pts) Circle any molecule that has an **overall molecular dipole moment**.



10. Provide an acceptable IUPAC name for the following molecules. Do not designate R or S for these.

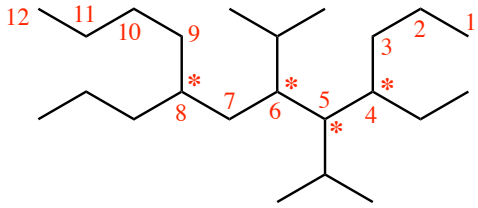
A) (7 pts)



8-ethyl-6-isopropyl-2,3,4-trimethyldecane
8-ethyl-2,3,4-trimethyl-6-(1-methylethyl)decane

Although stereochemistry is not indicated on the above structure, how many stereoisomers are possible? **8 (there are three chiral centers)**

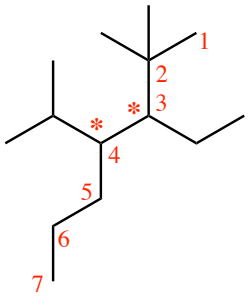
B) (7 pts)



4-ethyl-5,6-diisopropyl-8-propyldodecane
4-ethyl-5,6-(1-methylethyl)-8-propyldodecane

Although stereochemistry is not indicated on the above structure, how many stereoisomers are possible? **16 (there are four chiral centers)**

C) (7 pts)

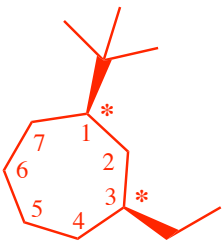


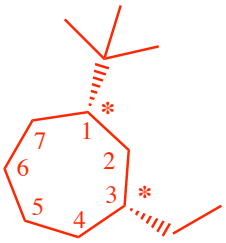
3-ethyl-4-isopropyl-2,2-dimethylheptane
3-ethyl-2,2-dimethyl-4-(1-methylethyl)heptane

Although stereochemistry is not indicated on the above structure, how many stereoisomers are possible? **4 (there are two chiral centers)**

11. (5 or 10 pts each) For the following IUPAC names, draw the appropriate line angle drawing (you can ignore R and S for the first two, but not the bottom one).

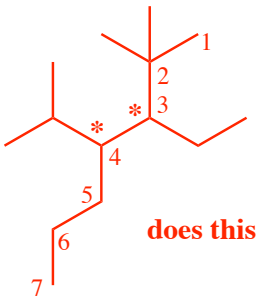
A) ***cis*-1-*tert*-butyl-3-ethylcycloheptane**





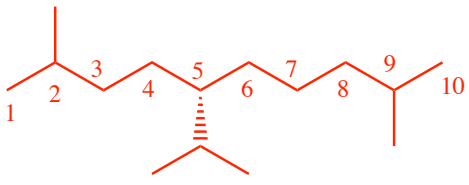
If the molecule you drew to the left is chiral, draw the enantiomer in this box.

B) **3-ethyl-2,2-dimethyl-4-(1-methylethyl)heptane**

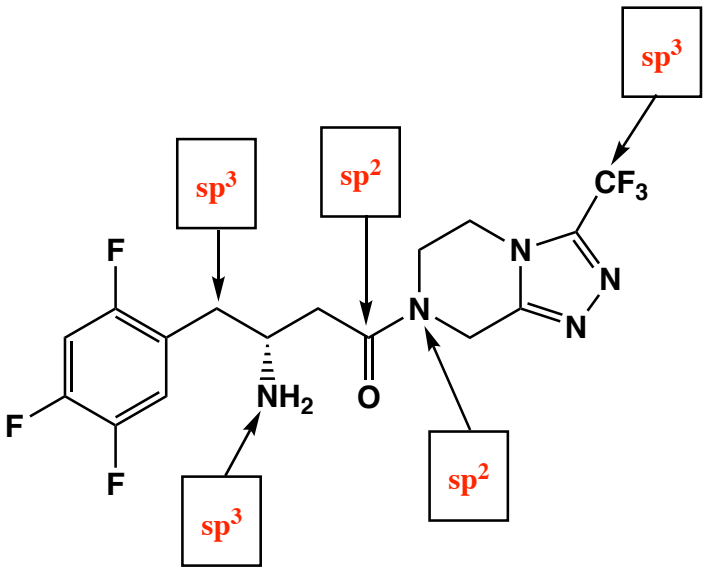


does this look familiar?

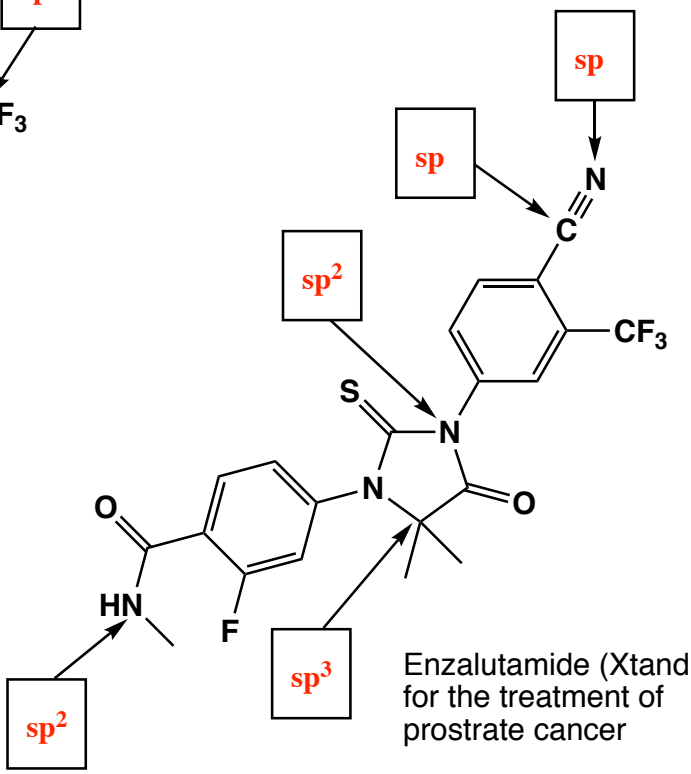
C) **(*S*)-5-isopropyl-2,9-dimethyldecane (Use wedges and dashes to indicate the appropriate stereochemistry at all chiral centers)**



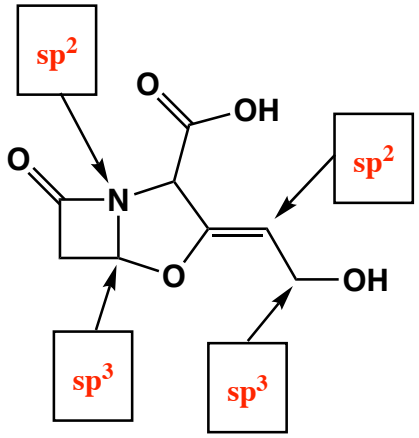
12. (1 pt each) In the boxes provided, write the hybridization state of the atoms indicated by the arrow.



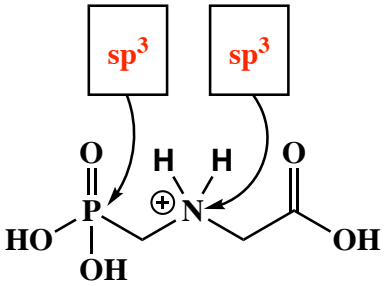
Sitagliptin (Januvia)
used to treat diabetes



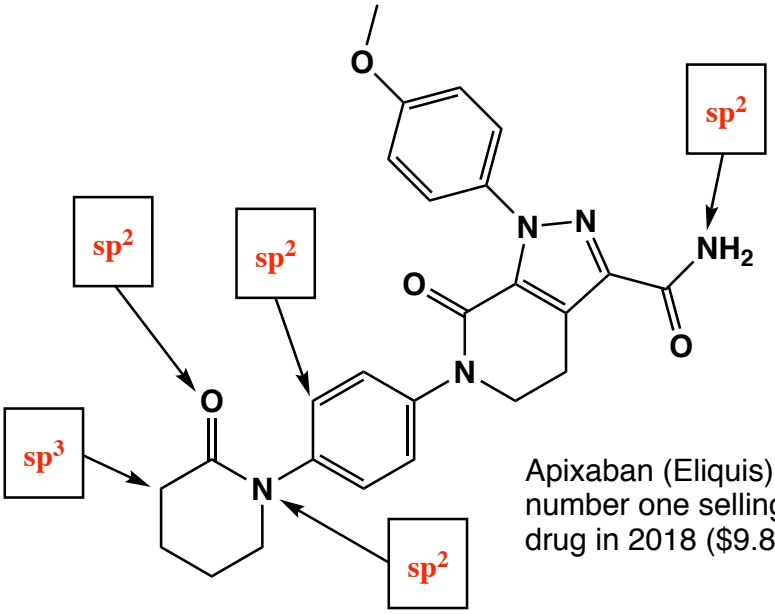
Enzalutamide (Xtandi)
for the treatment of
prostrate cancer



Augmentin used to treat
antibiotic resistant
bacterial infections

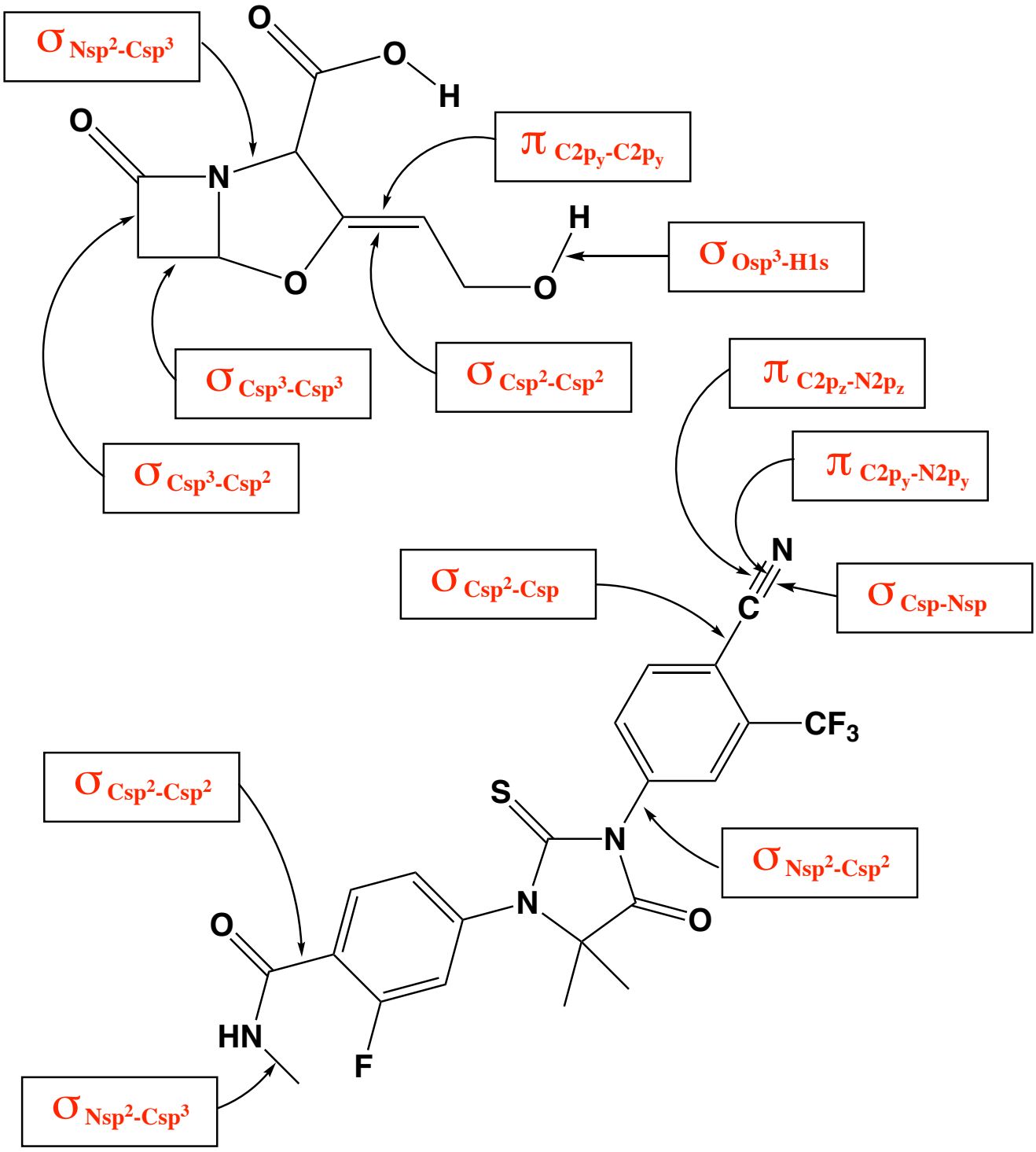


Glyphosate (Roundup the weedkiller)

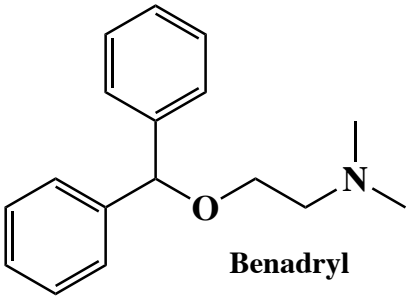


Apixaban (Eliquis) the
number one selling
drug in 2018 ($9.8 B)

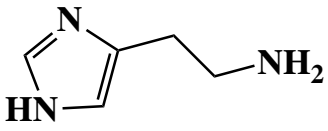
13. (2 pts each) Describe each bond indicated with an arrow as the overlap of hybridized orbitals. For example, an answer might be $\sigma_{Csp^3\text{-}Csp^3}$.



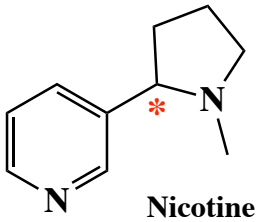
14. (20 pts) Circle all of the molecules that are chiral. **Put an asterisk next to all chiral centers.**



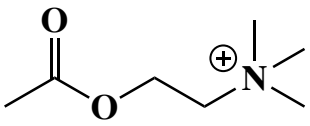
Benadryl



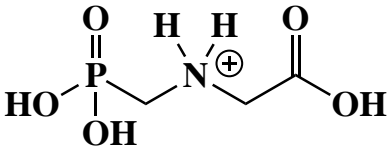
Histamine



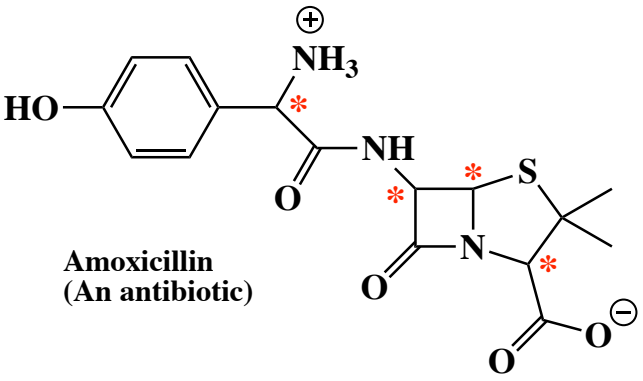
Nicotine



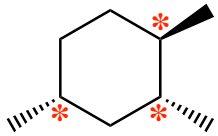
Acetyl choline

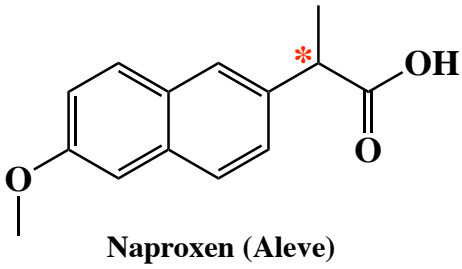


Glyphosate (Roundup the weedkiller)



Amoxicillin (An antibiotic)





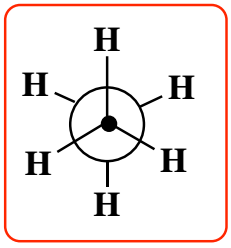
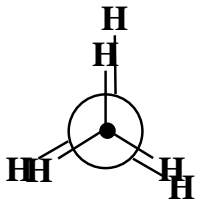
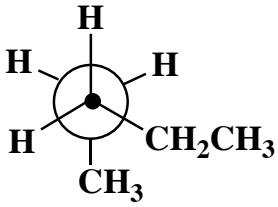
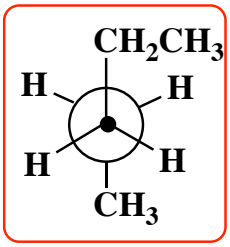
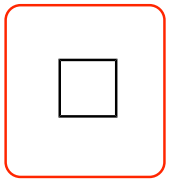
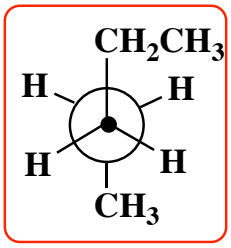
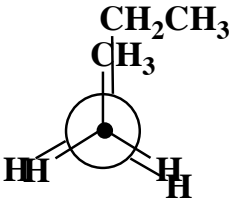
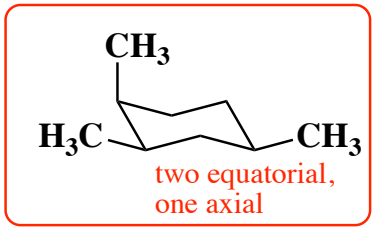
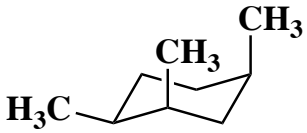
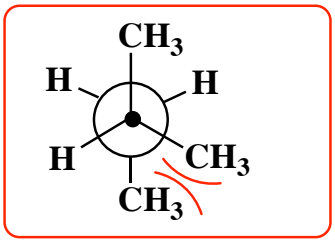
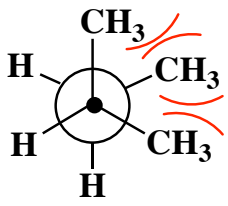
Naproxen (Aleve)

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

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

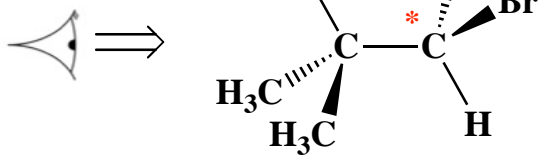
How many stereoisomers of Amoxicillin are possible? **16**

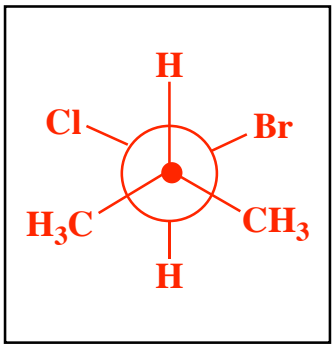
15. (4 pts each) For each pair of molecules, circle the one that has LESS STRAIN, then put an "X" in the box under all the types of strain that explain(s) your answer:

		Angle strain	Torsional strain	Steric strain
 vs. 		☐	X	☐
 vs. 		☐	☐	X
 vs. 		X	X	☐
 vs. 		☐	X	X
 two equatorial, one axial vs.  two axial, one equatorial		☐	☐	X
 one gauche interaction vs.  two gauche interactions		☐	☐	X

16. (5 pts) Draw the Newman projection for the conformation of 1-bromo-1-chloro-2-methylpropane as shown.

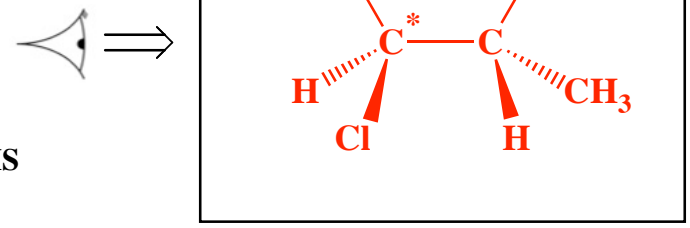
A)

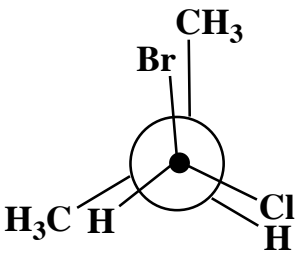




(7 pts) In the empty box draw the conformation of 1-bromo-1-chloro-2-methylpropane indicated by the Newman projection shown.

B)



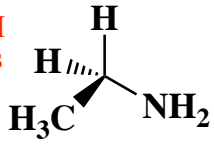


NOTICE THIS

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

17. (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.

two H atoms



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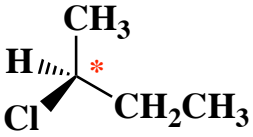
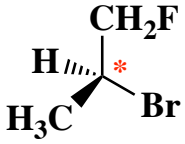
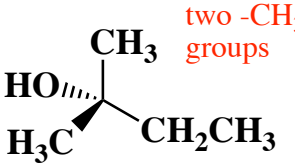


S

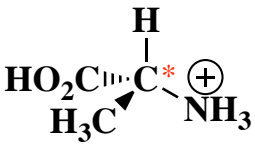


S

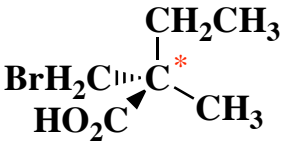
two -CH_3 groups



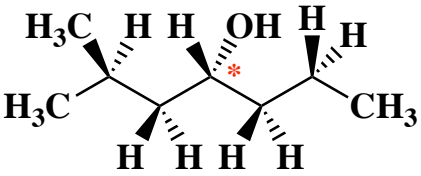
☐



R



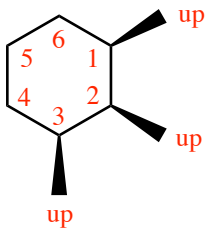
S



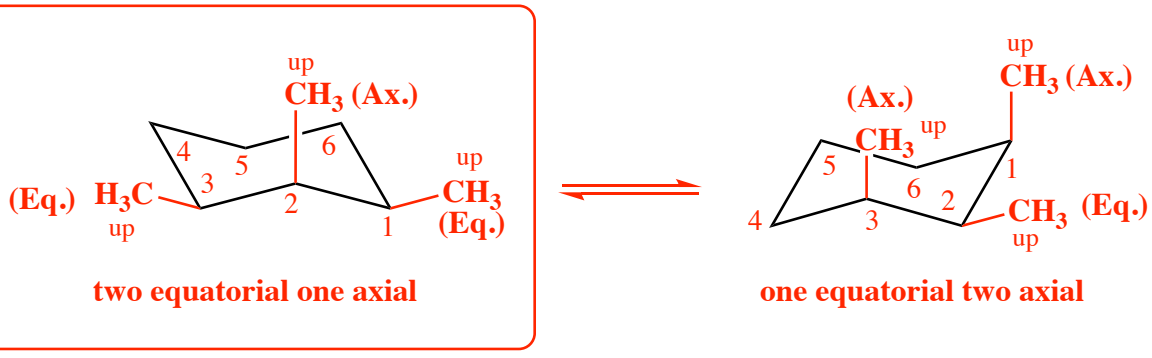
R

18. (18 pts) For the following cyclohexane derivatives, draw the two alternative chair conformations. IF there is a difference in stability, draw a circle around the more stable conformation. If there is not any difference in stability, do not circle either chair form.

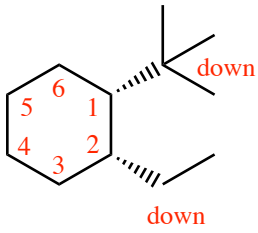
A)



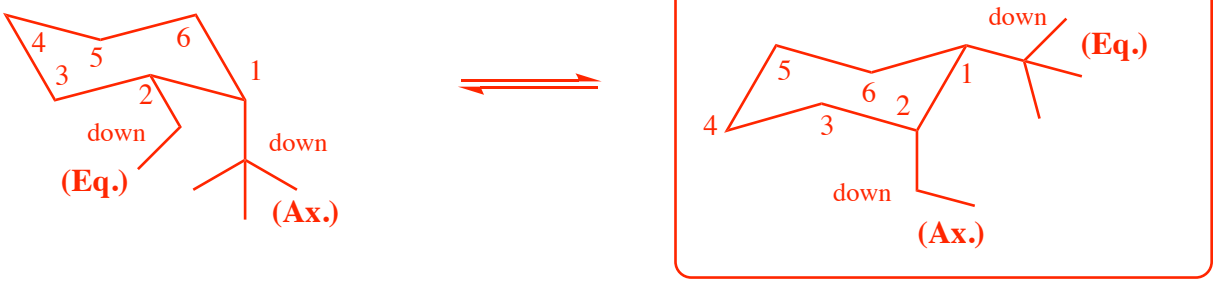
It is critical that you number in the same direction on all structures, I numbered clockwise here



B)

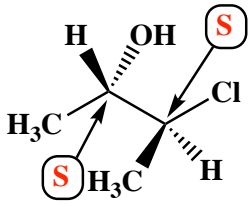


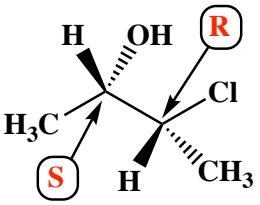
It is critical that you number in the same direction on all structures, I numbered clockwise here



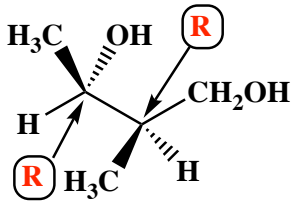
19. (37 pts) For each pair of molecules, on the line provided state the relationship between the two structures. Possible answers could be **enantiomers**, **diastereomers, consitutional isomers**, or **same molecule. Draw a circle around any meso compound. In the boxes provided next to each chiral center, write "R" or "S" to indicate the absolute stereochemistry present.**

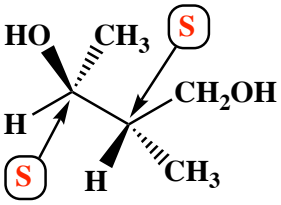
Relationship:



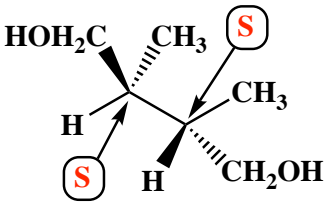


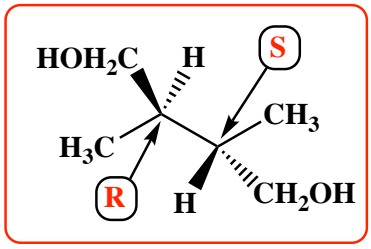
diastereomers





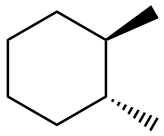
enantiomers

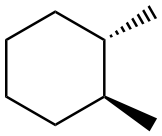




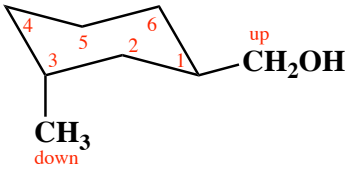
diastereomers

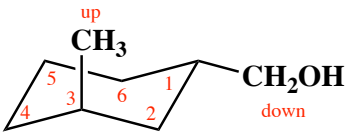
You do not need to label the chiral centers with "R" or "S" on these last three.



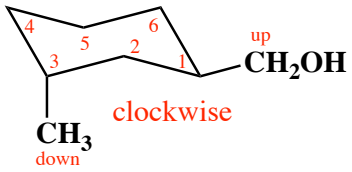


enantiomers

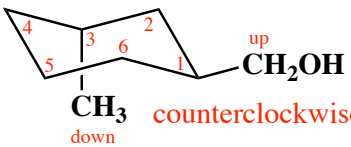




enantiomers



clockwise



counterclockwise

enantiomers

Notice how the numbers go in opposite directions between the two rings on the last one. That is why they are enantiomers.

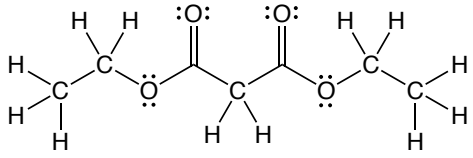
20. (20 points total). Here is an "apply what you know" problem in the form of an MCAT style passage.

We will spend a great deal of time this semester talking about the relative stabilities of different molecules and ions. So far, we have talked about stability as it relates to situations that are described by resonance contributing structures. In particular, we talked about two different Golden Rules of Chemistry that indicate why the situation described by resonance contributing structures is stabilizing. For both of these Golden Rules, the idea is that quantum mechanics predicts increased stabilization when either or both of two different things are spread onto more atoms. For the following questions, circle the best answer.

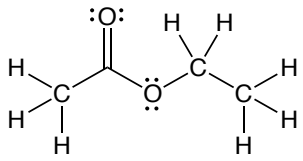
1. (4 pts) From the following choices, select the answer choice below that most accurately describes what we discussed as being stabilizing when spread onto more atoms?

A. Charge and pi electron density.
B. Charge and sigma bonding density.
C. Charge and hybridization.
D. Charge and valence electrons.

The following molecules are called diethylmalonate and ethyl acetate.

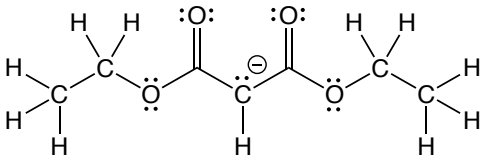


Diethyl malonate

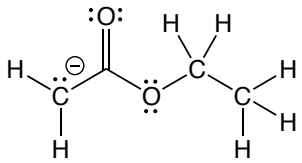


Ethyl acetate

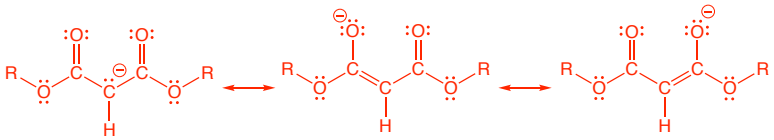
At one time, diethyl malonate was used quite a bit in organic synthesis. One of the reasons is that diethyl malonate can have a proton removed to create an anion. That anion can then react in characteristic ways to make new C-C bonds. Creating new C-C bonds is how chemists can assemble smaller fragments to make larger, more complex molecules. Most modern syntheses of complex molecules are based on strategizing over exactly when and how new C-C bonds are made. Below is the structure of the anions produced when a proton is removed from diethyl malonate and ethyl acetate.



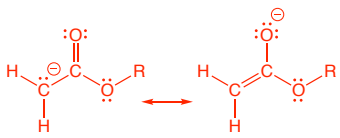
Diethyl malonate anion



Ethyl acetate anion



The negative charge is spread over one C and two O atoms, and the "pi-way" is larger. Three important contributing structures, more stable.



The negative charge is spread over one C and one O atoms, and the "pi-way" is smaller. Two important contributing structures, less stable.

20. (cont.) Circle the best response

2. (4 pts): Of the following, which statement is true?

A. Neither the diethyl malonate anion nor the ethyl acetate anion are best described through the use of important contributing structures.
B. Both the diethyl malonate anion and the ethyl acetate anion are best described by the same number of important contributing structures.
C. The ethyl acetate anion is best described by a larger number of important contributing structures than the diethyl malonate anion.
D. The diethyl malonate anion is best described by a larger number of important contributing structures than the ethyl acetate anion.

3. (4 pts) Because of your answer to part 2) above, which of the following best describes the situation.

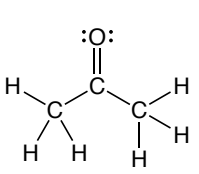
A. Both the diethyl malonate anion and the ethyl acetate anion are too unstable to isolate.
B. The diethyl malonate anion and the ethyl acetate anions are of roughly equal stability.
C. The ethyl acetate anion is more stable than the diethyl malonate anion.
D. The diethyl malonate anion is more stable than the ethyl acetate anion.

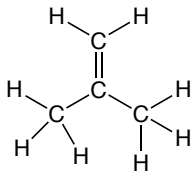
Soon, we will learn that all things being equal, an acid is stronger if removal of its proton gives rise to a more stable anion.

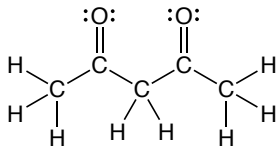
4. (4 pts) Based on your previous answers, predict which of the following are true:

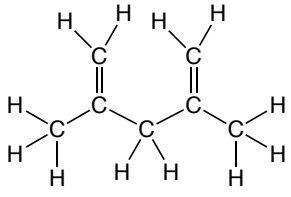
A. Neither diethyl malonate nor ethyl acetate can lose a proton without falling apart.
B. Diethyl malonate and ethyl acetate are equally acidic.
C. Ethyl acetate is more acidic than diethyl malonate.
D. Diethyl malonate is more acidic than ethyl acetate.

Consider the following three molecules:


Molecule A


Molecule B


Molecule C


Molecule D

5. (4 pts) Based on everything you know, predict which of the following are true:

A. Molecule A is the most acidic.
B. Molecule B is the most acidic.
C. Molecule C is the most acidic.
D. Molecule D is the most acidic.

The key to this question is that, as shown on the previous page, the anion of the molecule with two C=O groups (C) has three stabilizing and important contributing structures while the anion of molecule with one C=O group (A) only has two. As established above, that makes the anion of C more stable than that of A, so C is more acidic than A. Molecules B and D are not going to give more stable anions, because they do not have eletronegative O atoms on the pi bonds to accept the negative charge in contributing structures, only C atoms.

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!!!