

NAME (Print): _____

Chemistry 320M/328M
Dr. Brent Iverson
1st Midterm
September 24, 2026

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!

In this class students may not wear, access or use smart devices, artificial intelligence (AI) tools, or any other hand-written or external source of information or assistance during examinations.

This applies regardless of whether the device is actively being used or whether any use is observed: **Simply wearing a smart device during a quiz or exam constitutes a violation of this policy**, even if the student does not interact with it and is not seen doing so. Smart devices include, but are not limited to, smartphones, smartwatches, smart glasses, tablets, earbuds or other connected audio devices, and any other electronic device capable of storing, transmitting, receiving, or accessing information.

Student Honor Code

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.

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 the academic and scholarly endeavors of the University community.

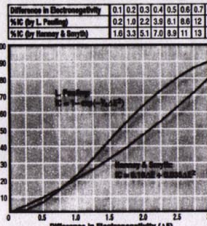
(Your Signature)

PERIODIC TABLE OF THE ELEMENTS

▼ Elementary Subatomic Particles

[illegible]

▼ % Ionic Character of a Single Chemical Bond



0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
15	18	22	26	30	34	39	43	48	56	69	83	67	40	75	76	79	82	64	66	68	69	91	92
17	20	22	24	27	29	32	35	37	40	43	46	49	52	55	58	62	65	68	72	76	80	83	87

Percent loss character describes the nature of a band. Bands possessing 50% or greater loss character are commonly termed toxic; bands with less than 50% loss character are termed cosmetic. Pauling's equation was modified by Harvey

and Smyth in order to achieve better agreement between experimental and calculated values. Transition from toxic to cosmetic bonding is usually accompanied by a reduction in electrical conductance, melting point and boiling point.

18
VIII
0

4.002602 2
-272.23mm
-268.93

[illegible][illegible]

Editors: T. K. Varga, M.A.Sc. & C. Bello, M.A.Sc.
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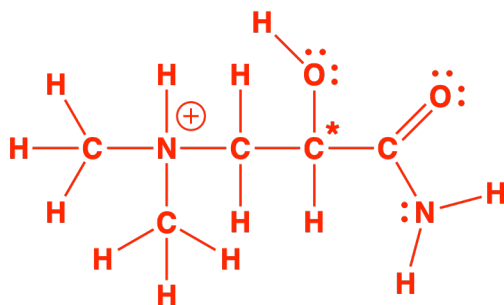
PAPERTECH

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

Where are the electrons?

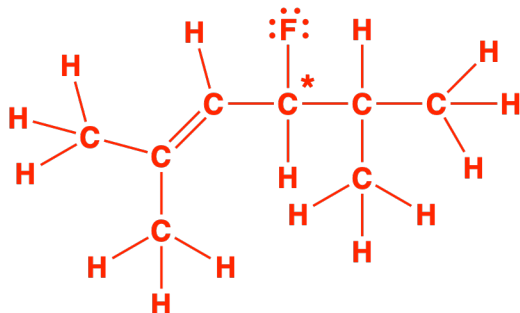
2. (8 pts each) For the following molecular formula, draw complete Lewis line structures in which all atoms (even H atoms) are drawn, lines are used as bonds, all lone pairs are drawn AND ALL FORMAL CHARGES ARE INDICATED. Note you must infer the formal charges as we do not indicate them on the chemical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

1) $(\text{CH}_3)_2\text{NHCH}_2\text{CHOHCONH}_2$



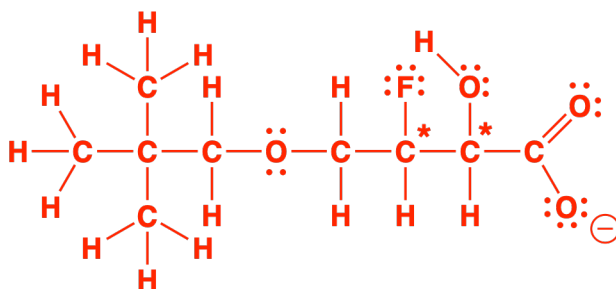
How many different stereoisomers are possible for the above molecule? 2

2) $(\text{CH}_3)_2\text{CCHCH}_2\text{FCH}(\text{CH}_3)_2$



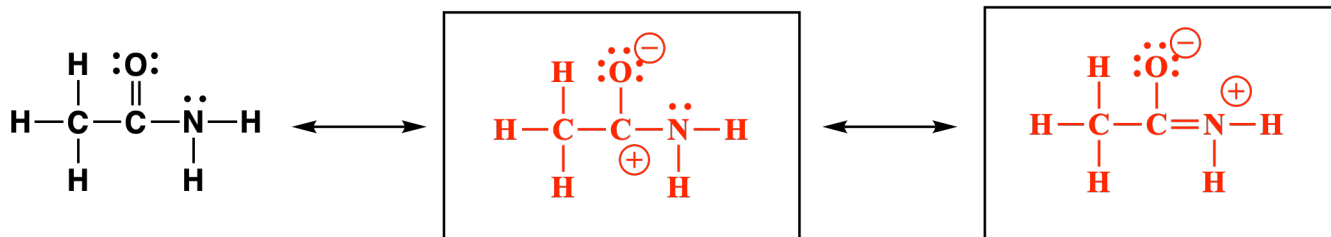
How many different stereoisomers are possible for the above molecule? 2

3) $(\text{CH}_3)_3\text{CCH}_2\text{OCH}_2\text{CHFCHOHCO}_2$



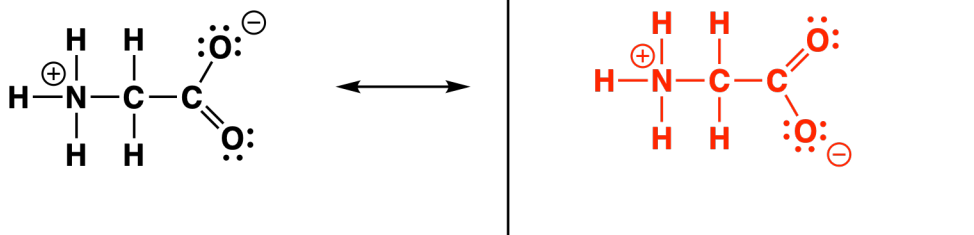
How many different stereoisomers are possible for the above molecule? 4

3. (6 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.

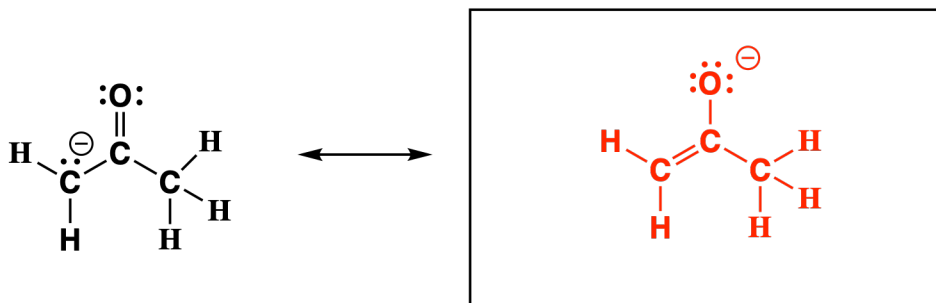


4. (6 pts) The following molecules are best represented as the hybrid of contributing structures. **Draw the second important contributing structure** in the space provided, including all lone pairs and formal charges.

A.

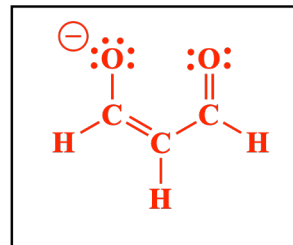
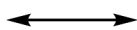
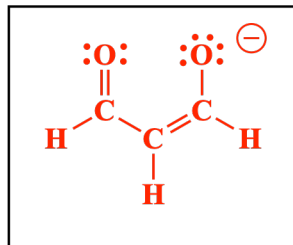
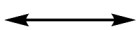
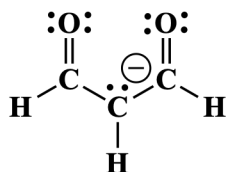


B.

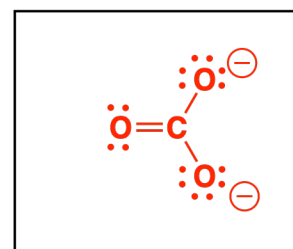
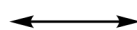
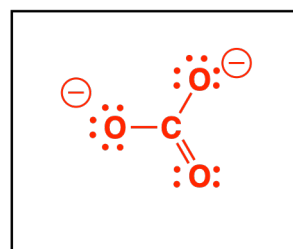
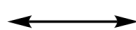
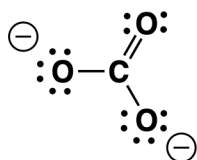


5. (12 pts) The following molecules are best represented as the hybrid of three contributing structures. Draw the **second and third important contributing structures** in the spaces provided, including all lone pairs and formal charges.

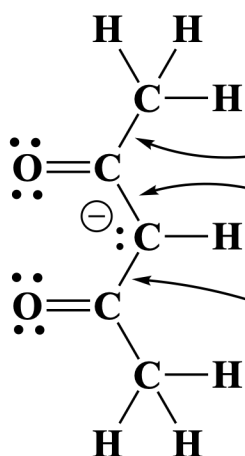
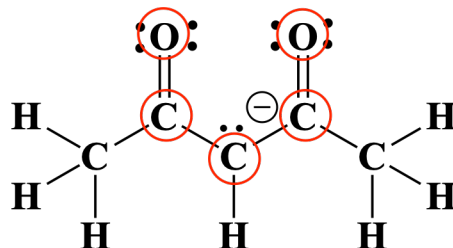
A.



B.



6. (15 pts) On the following molecule, circle all the atoms that are sp^2 hybridized and answer the three questions in the boxes provided by filling in the circles next to the correct answers.



Does this bond rotate at room temperature?

☒ Yes
☐ No

Does this bond rotate at room temperature?

☐ Yes
☒ No

Does this bond rotate at room temperature?

☐ Yes
☒ No

How many atoms are in the "pi-way"
(extended pi bonding) of this molecule?

☐ none ☐ 4
☐ 2 ☒ 5
☐ 3 ☐ 6

7. (1 pt 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.

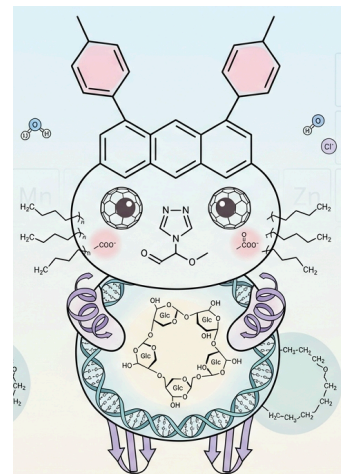
The wave functions for the valence atomic orbitals on each atom can be added together first, a process referred to as hybridization, before looking for overlap with orbitals from other atoms. This approach is called valence bond theory.

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.

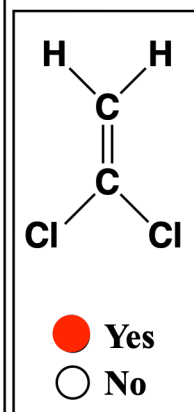
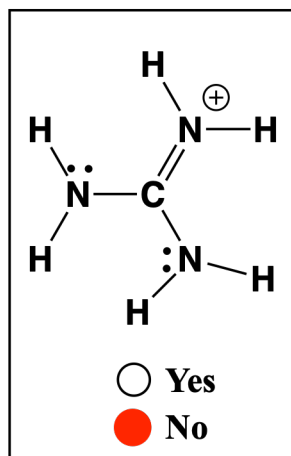
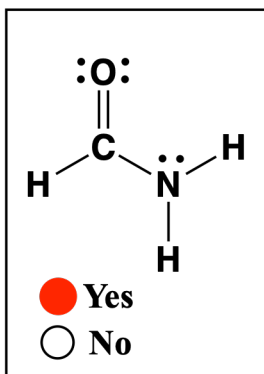
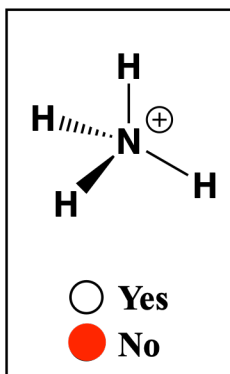
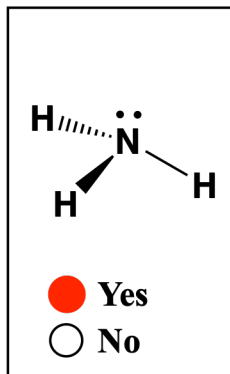
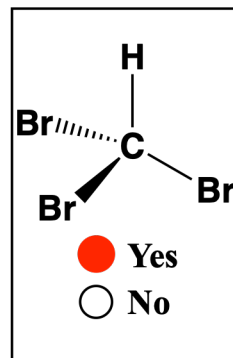
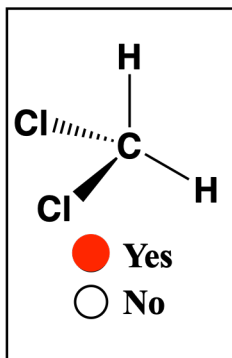
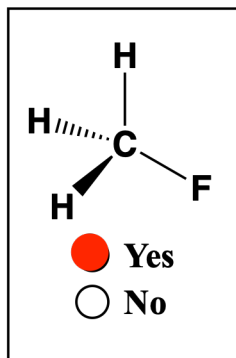
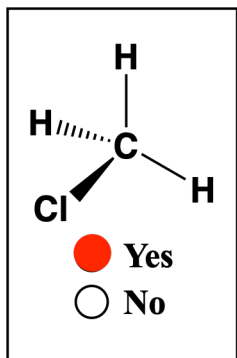
Especially for charged molecules, it is stabilizing to have pi electron density as well as charges delocalized over more than two atoms. This concept is usually referred to as "stabilization due to delocalization" or simply "resonance stabilization".

For pi bonding and therefore pi delocalization to occur over more than two atoms (i.e. pi-systems), parallel 2p orbitals are needed on ALL of the adjacent atoms involved, explaining why ALL of these atoms must be sp² (or sp) hybridized and why these systems are planar and none of the bonds involved can rotate.

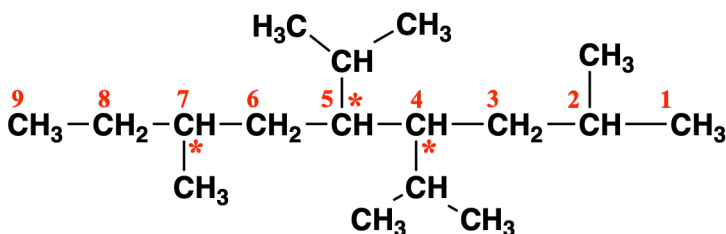
Here is a cute chemical creature generated by AI. Nothing for you to do here but I wanted to bring you a smile during the exam!



8. (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.



9. (7 pts) Provide an acceptable IUPAC name for the following molecule. Do not designate R or S for this.

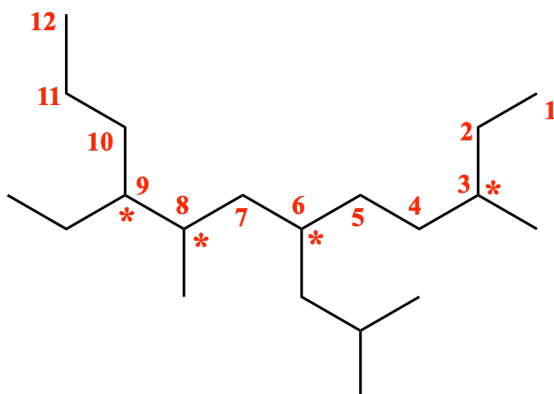


4,5-diisopropyl-2,7-dimethylnonane
or **2,7-dimethyl-4,5-di(1-methylethyl)nonane**

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

$2^3 = 8$

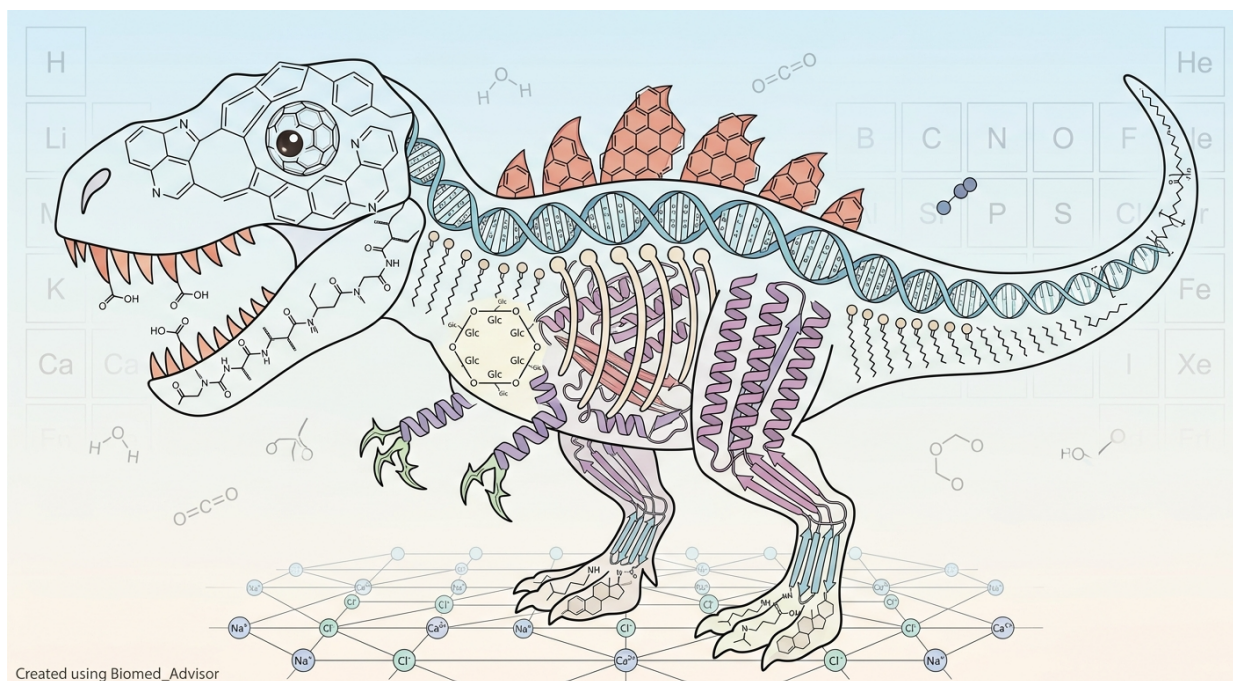
10. (7 pts) Provide an acceptable IUPAC name for the following molecule. Do not designate R or S for this.



**9-ethyl-6-isobutyl-3,8-dimethyldodecane
or 9-ethyl-3,8-dimethyl-6-(2-methylpropyl)dodecane**

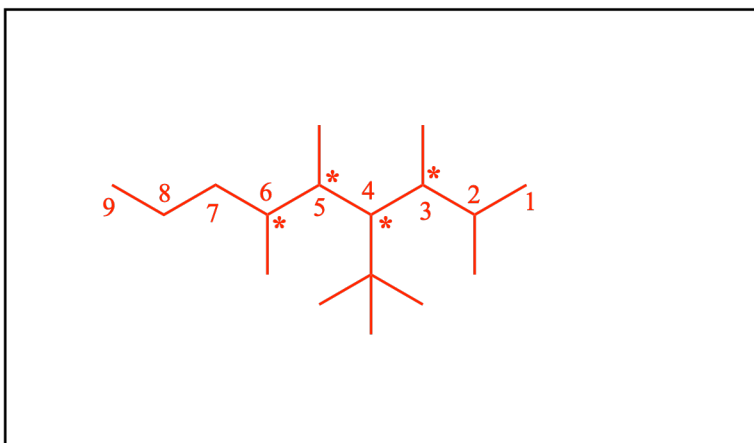
Although stereochemistry is not indicated on the above structure, how many stereoisomers are possible?

$$2^4 = 16$$



11. (10 pts each) For the following IUPAC name, draw the appropriate line angle drawing. You can ignore R and S for this one.

4-(*tert*-butyl)-2,3,5,6-tetramethylnonane

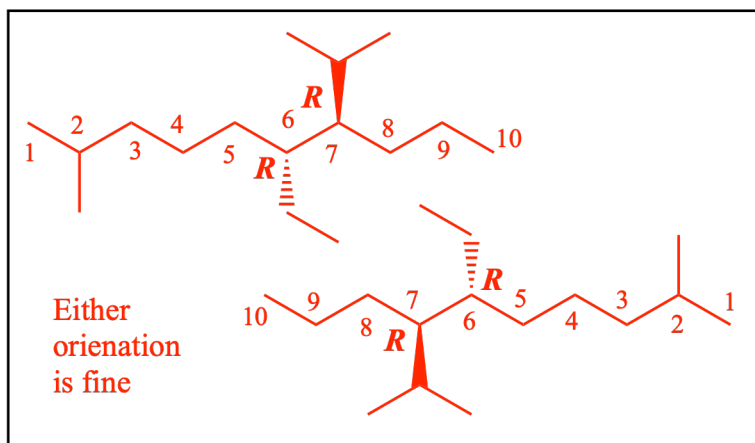


Although stereochemistry is not indicated in the above name or your structure, how many stereoisomers are possible?

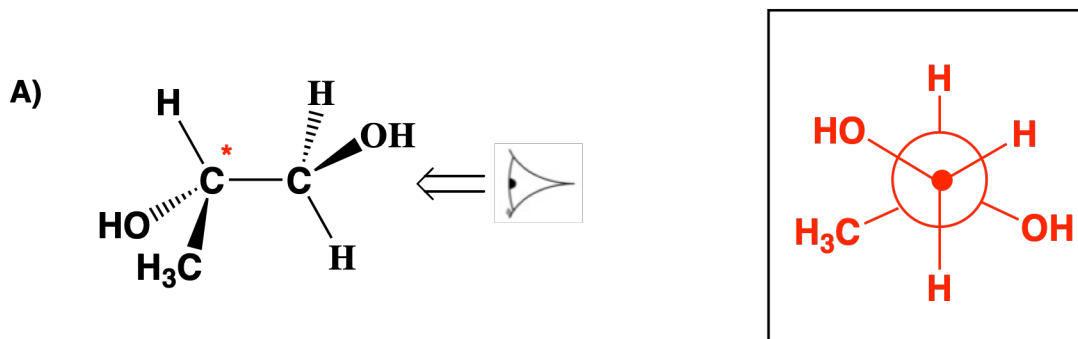
$$2^4 = 16$$

12. (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.

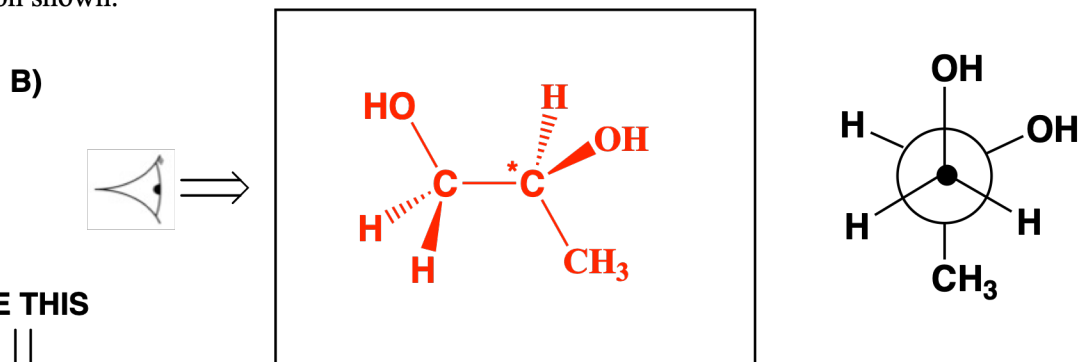
(6*R*,7*R*)-6-ethyl-7-isopropyl-2-methyldecane



13. (5 pts) Draw the Newman projection for the conformation of propane-1,2-diol.



(7 pts) In the empty box draw the conformation of propane-1,2-diol indicated by the Newman projection shown.



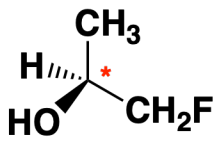
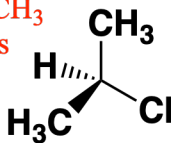
NOTICE THIS



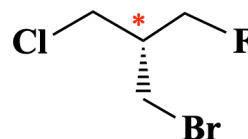
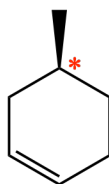
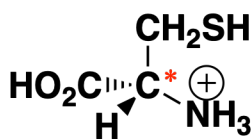
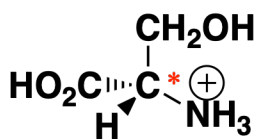
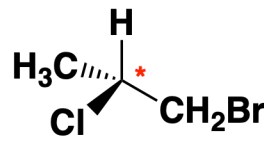
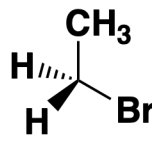
The same molecule was used in both parts of this problem. It is chiral, is it R or S? **S**

14. (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.

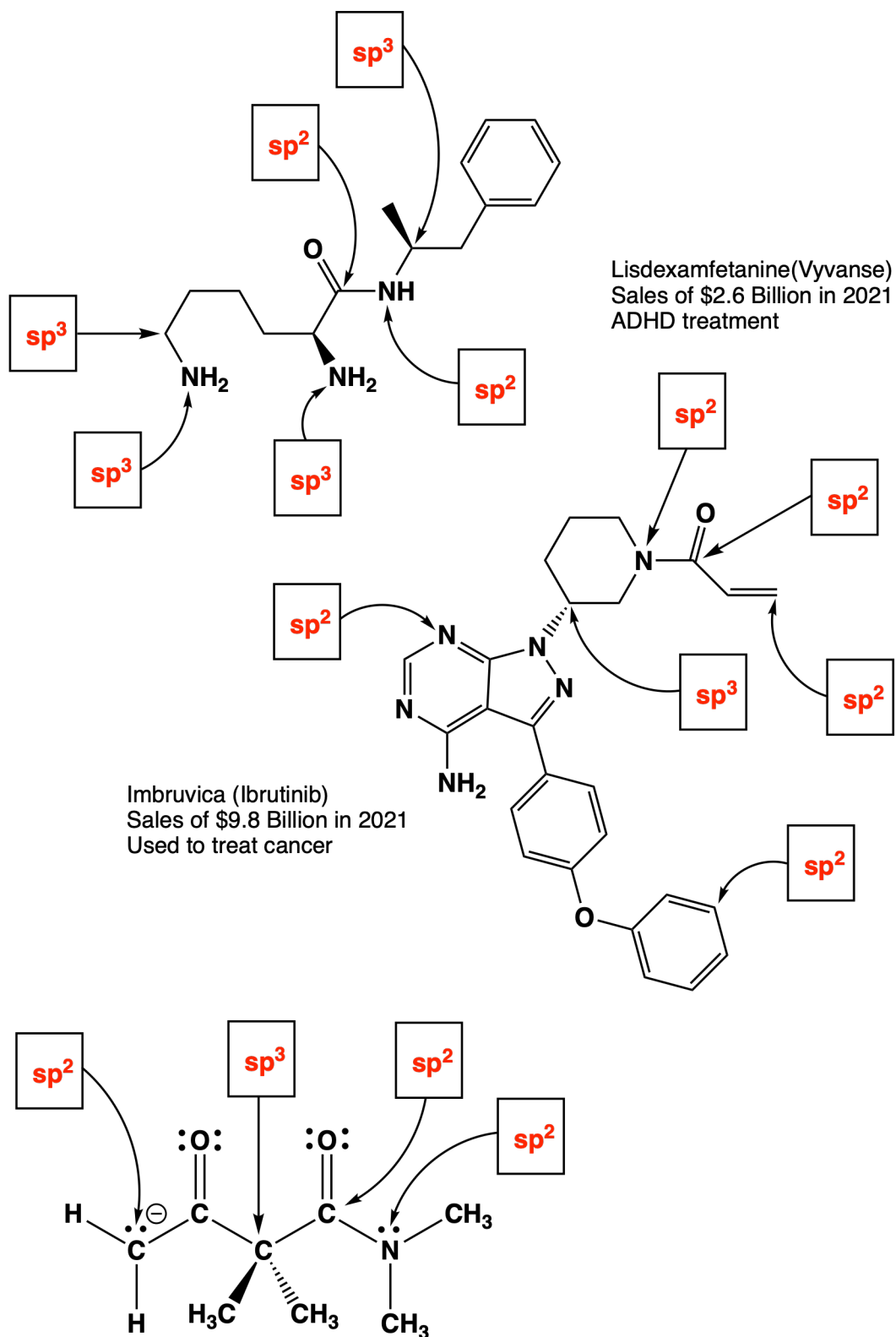
two -CH₃
groups



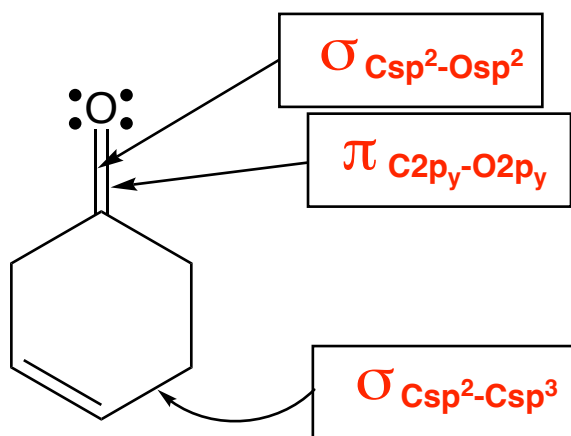
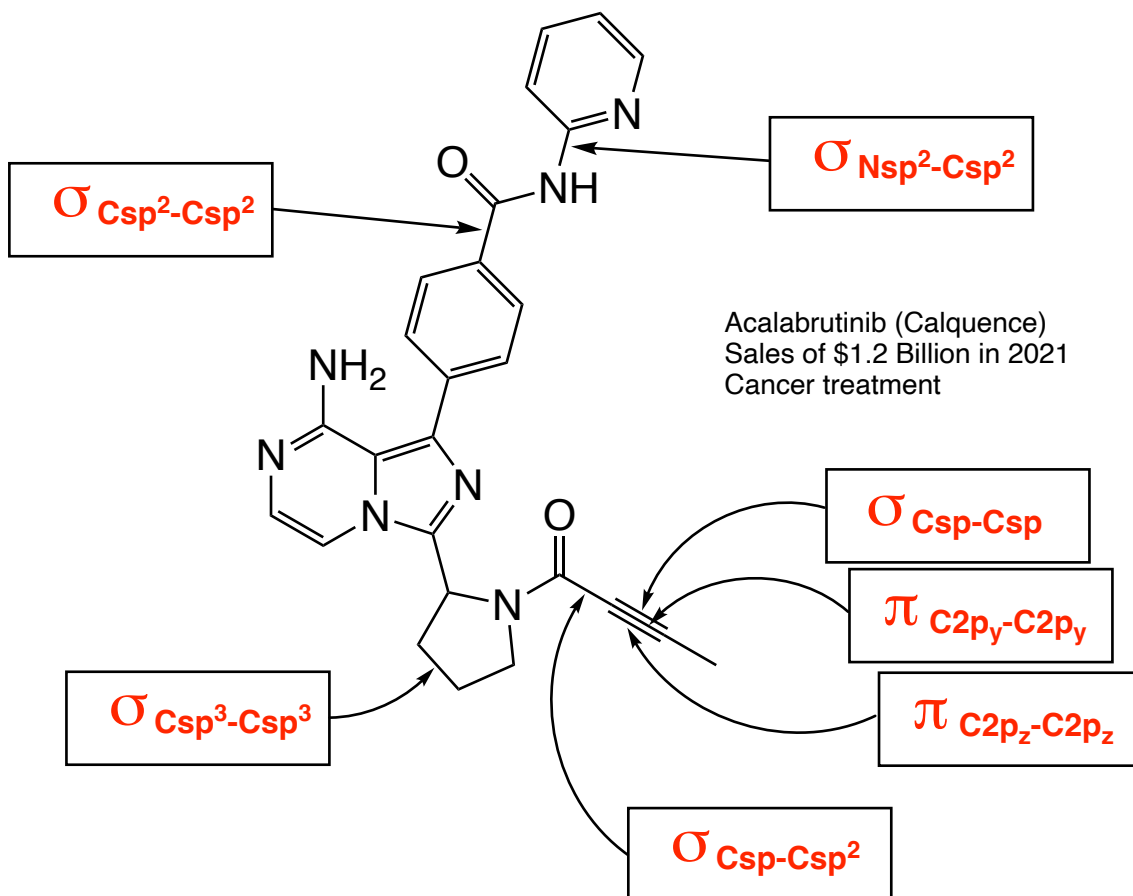
two -H
groups



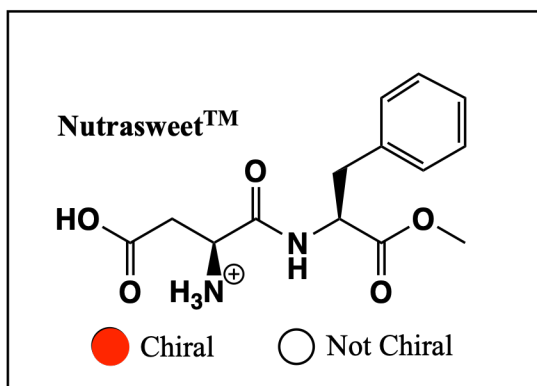
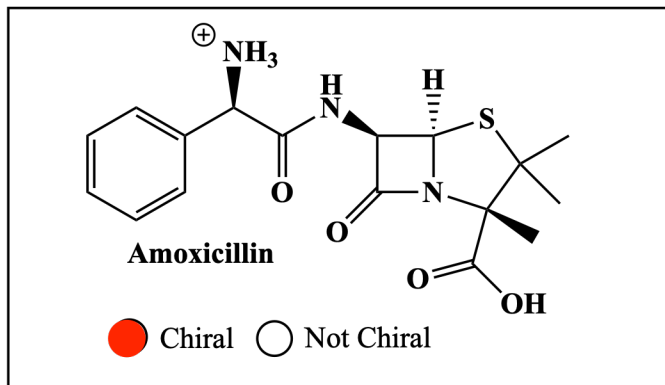
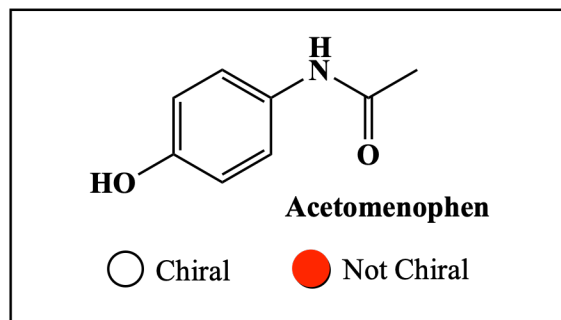
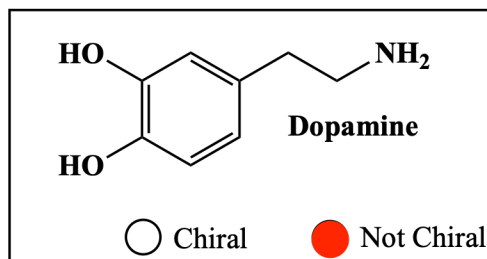
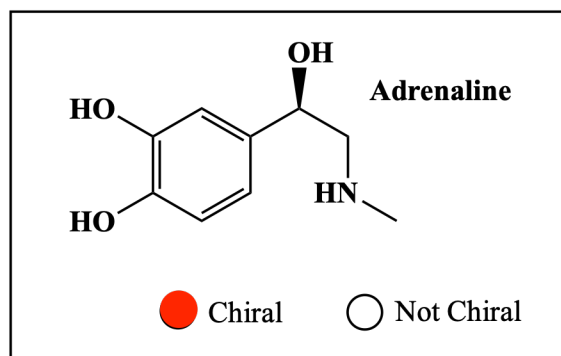
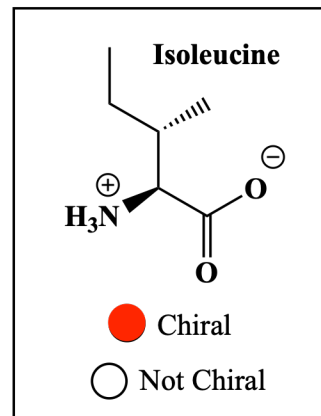
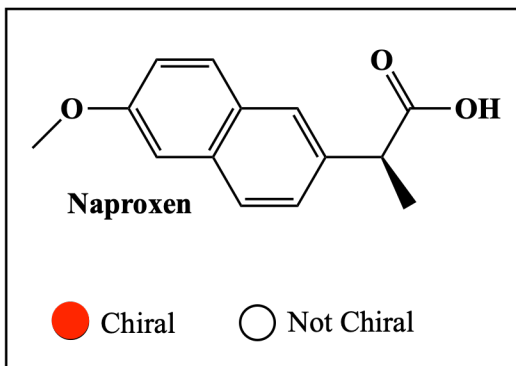
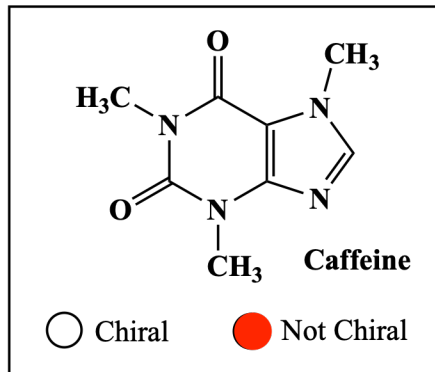
15. (1 pt each) In the boxes provided, write the hybridization state of the atoms indicated by the arrow.



16. (2 pts each) Describe each bond indicated with an arrow as the overlap of orbitals. For example, an answer might be $\sigma_{\text{Csp}^3-\text{Csp}^3}$



17. (22 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 Isoleucine are possible?

4

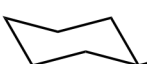
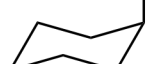
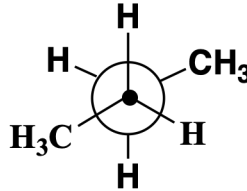
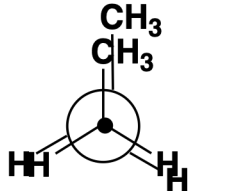
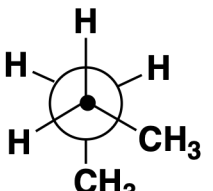
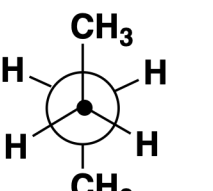
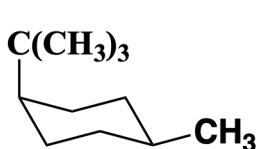
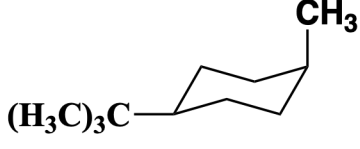
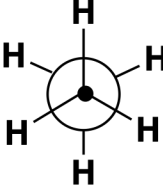
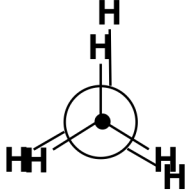
How many stereoisomers of acetomenophen are possible?

1

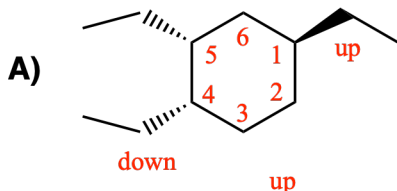
How many stereoisomers of Amoxicillin are possible?

16

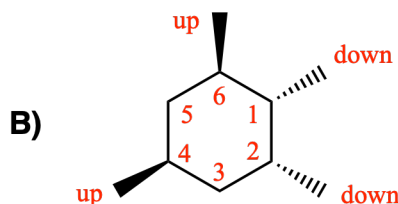
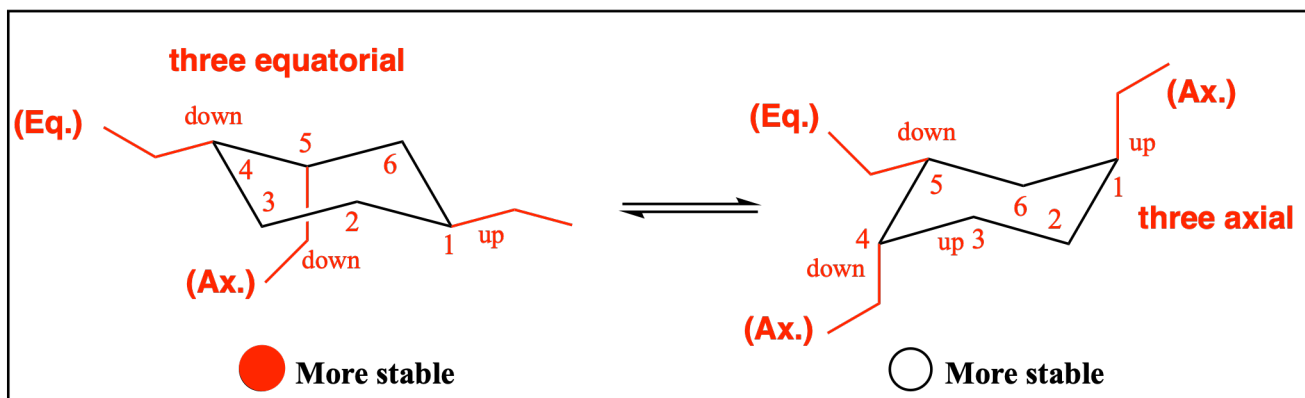
18. (4 pts each) For each pair of molecules, fill in the circle under the one that is more stable of the two, then put an "X" in the box under all the types of strain that explain(s) your answer:

			Angle strain	Torsional strain	Steric strain
 ☒ More stable	vs.	 ☐ More stable	☐	☐	☒
 ☒ More stable	vs.	 ☐ More stable	☐	☒	☒
☐ More stable	vs.	 ☒ More stable	☒	☒	☐
 ☐ More stable	vs.	 ☒ More stable	☐	☐	☒
 ☐ More stable	vs.	 ☒ More stable	☐	☐	☒
 ☒ More stable	vs.	 ☐ More stable	☐	☒	☐

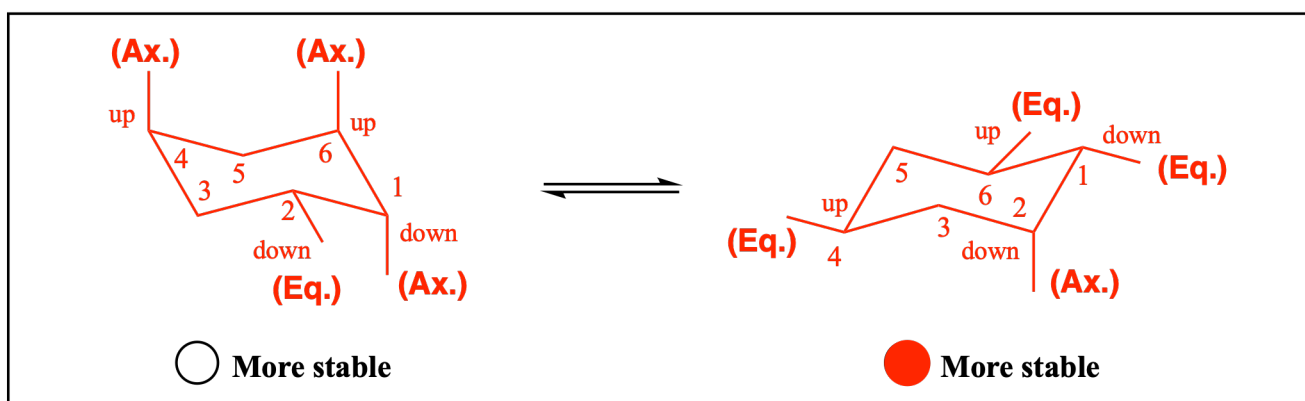
19. (20 pts) For the following cyclohexane derivatives, draw the two alternative chair conformations. If there is a difference in stability, fill in the circle that says "More stable". If there is not any difference in stability, do not fill in any circle.



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



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



20. (38 pts) For each pair of molecules, on the line provided state the relationship between the two structures. Possible answers could be **enantiomers**, **diastereomers**, **constitutional isomers**, or **same molecule**. Fill in the circle to indicate the correct relationship between the molecules shown. In the boxes provided next to each chiral center, write "R" or "S" to indicate the absolute stereochemistry present.

Relationship:

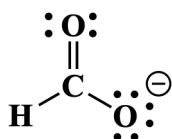
	☒ enantiomers ☐ diastereomers ☐ constitutional isomers ☐ same molecule
	☐ enantiomers ☐ diastereomers ☐ constitutional isomers ☒ same molecule
	☒ enantiomers ☐ diastereomers ☐ constitutional isomers ☐ same molecule
	☐ enantiomers ☒ diastereomers ☐ constitutional isomers ☐ same molecule

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

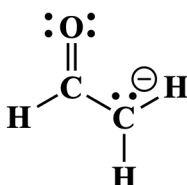
	☒ enantiomers ☐ diastereomers ☐ constitutional isomers ☐ same molecule
	☒ enantiomers ☐ diastereomers ☐ constitutional isomers ☐ same molecule

21. (2 or 4 pts each) Here is an “apply what you know” problem in the form of an MCAT style passage.

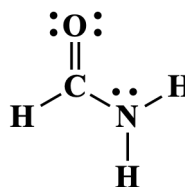
We have seen a number of molecules that contains a three-atom, delocalized pi bond (a “pi-way”). In particular, we have seen a carboxylate ion, enolate ion, and of course, amides. Each of the three atoms donates a $2p$ orbital and these add to make the delocalized pi bonds.



Carboxylate Ion

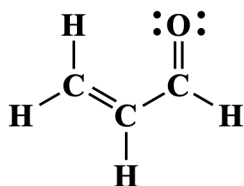


Enolate Ion

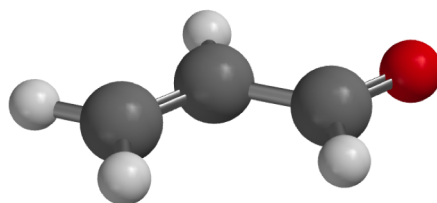


Amide

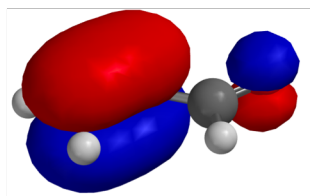
When the three $2p$ orbitals overlap, there are three pi molecular orbitals formed that extend over all three atoms. Now we will consider a related situation in which there are four atoms involved, not three.



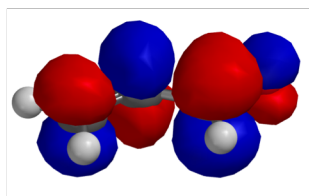
**Acrolein
(Propenal)**



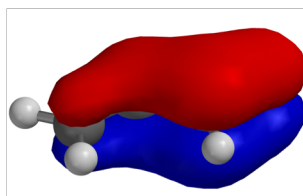
The molecule has the common name acrolein and the IUPAC name of propenal. It is highly reactive in two important reactions we will learn: A Michael reaction and the Diels-Alder reaction. It is used as a herbicide and it is easily polymerized to make plastics. Because of this reactivity, it is highly toxic so it needs to be handled with extreme care. Below are the four molecular orbitals of the delocalized pi bonding (“pi-way”) of acrolein.



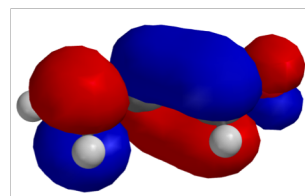
A



B



C



D

A) Of the above orbitals, fill in the circle to indicate which is the **lowest** in energy.

- ☐ Orbital A ☐ Orbital B ☒ Orbital C ☐ Orbital D

B) Of the above orbitals, fill in the circle to indicate which is the **highest** in energy.

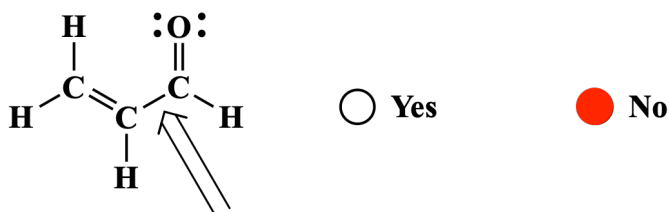
- ☐ Orbital A ☒ Orbital B ☐ Orbital C ☐ Orbital D

21 (cont).

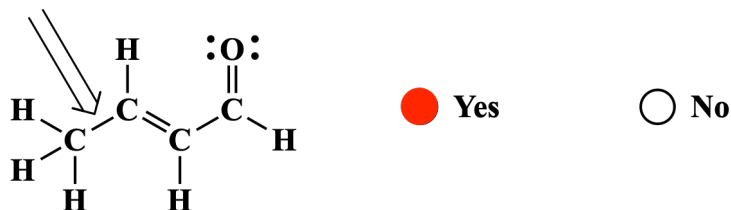
- C) For the above analysis, fill in the circle to indicate how many different $2p$ orbital wave functions were involved in creating the molecular orbitals shown.

☐ 2 ☐ 3 ☒ 4 ☐ 5

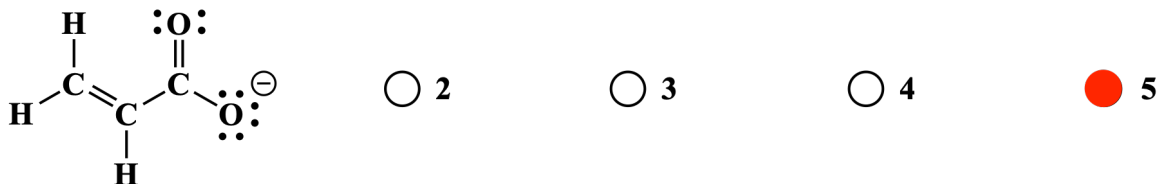
- D) In acrolein, would the bond indicated by the arrow rotate freely at room temperature?



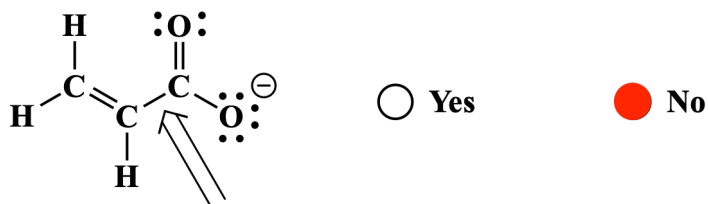
- E) In the molecule shown below that is related in structure to acrolein, would the bond indicated by the arrow rotate freely at room temperature?



- F) Consider the molecule shown below. It also has extensive delocalized π bonding. Fill in the circle to indicate how many $2p$ orbital wave function are involved in creating the π molecular orbitals (“ π -way”) of this molecule.



- G) In the same molecule, would the bond indicated by the arrow rotate freely at room temperature?



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!!!