NAME (Print): _____

SIGNATURE: _____

**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 xerox 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		(20)
2		(22)
3		(15)
4		(17)
5		(30)
6		(30)
7		(20)
8		(18)
9		(23)
10		(16)
11		(20)
12		(17)
13		(23)
14		(20)
15		(12)
16		(4)
Total		(307)

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."
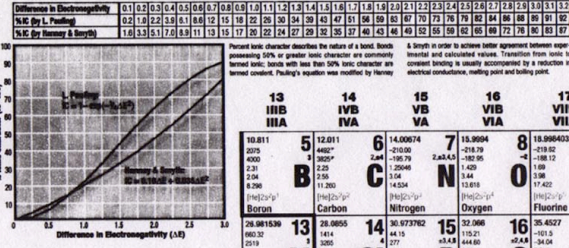
_____
(Your signature)

PERIODIC TABLE OF THE ELEMENTS

▼ Elementary Subatomic Particles

Symbol		Electron	Proton	Neutron	Photon	Neutrino
		e	p	n	γ	ν
Rest mass (kg)		9.1093897(54) x 10⁻³¹	1.6726231(10) x 10⁻²⁷	1.6749286(10) x 10⁻²⁷	0	≈0
Molar mass (kg/mol)		5.48579903(13) x 10⁻⁷	1.007276470(12) x 10⁻³	1.008664904(14) x 10⁻³	0	≈0
Particle-electron mass ratio		1	1.007276470(37)	1838.152701(37)	0	≈0
Particle-proton mass ratio		5.44617013(11) x 10⁻⁴	1	1.001378404(9)	0	≈0
Particle-neutron mass ratio		5.438673x10⁻⁴	0.998624	1	0	≈0
Specific charge (C/kg)		−1.75881962(53) x 10⁺¹¹	9.5788309(29) x 10⁺⁷	0	0	≈0
Radius (m)		<1 x 10⁻¹⁸	8 x 10⁻¹⁶	8 x 10⁻¹⁶	0	≈0
Spin quantum number		1/2	1/2	1/2	1	1/2

▼ % Ionic Character of a Single Chemical Bond

Difference in Electronegativity	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	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

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) $CH_3CH_2CHBrCH_2COCH_3$
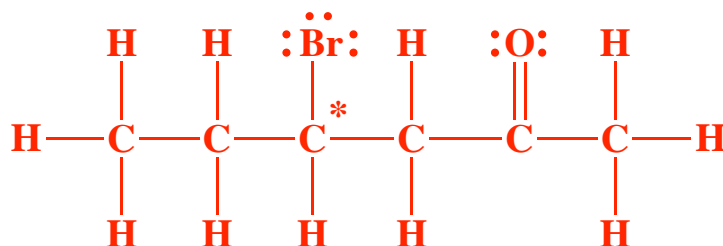
How many different stereoisomers are there for the above molecule? **2**

2) $CH_2OHCHNH_3CO_2CH_3$

This is the methyl ester of the amino acid serine
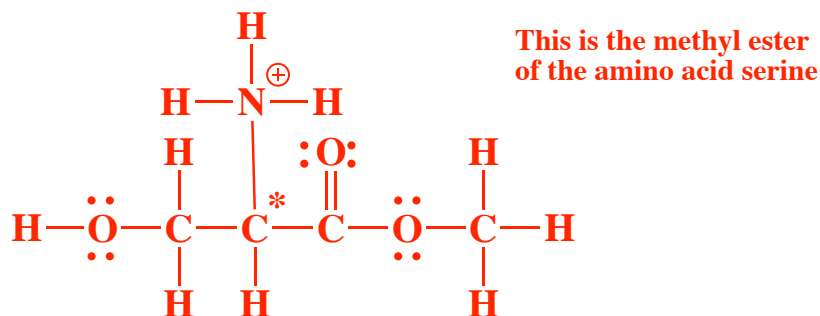
How many different stereoisomers are there for the above molecule? **2**

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

A) (6 pts)
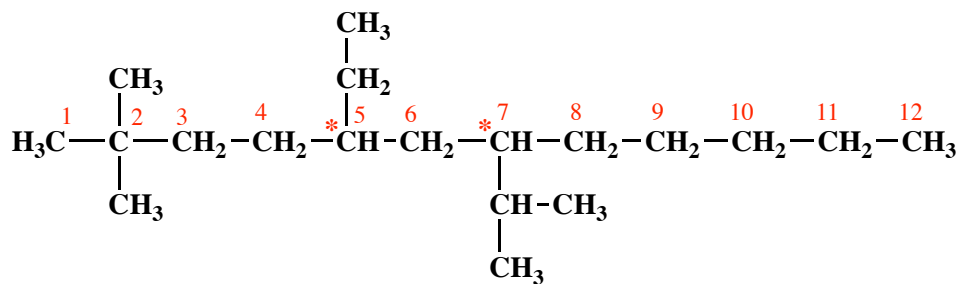
5-ethyl-7-isopropyl-2,2-dimethyldodecane
5-ethyl-2,2-dimethyl-7-(1-methylethyl)dodecane

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

B) (6 pts)
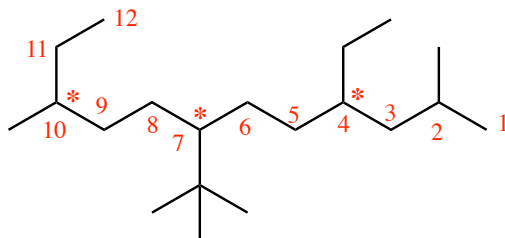
7-(*tert*-butyl)-4-ethyl-2,10-dimethyldodecane
4-ethyl-2,10-dimethyl-7-(1,1-dimethylethyl)dodecane

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

C) (10 pts)
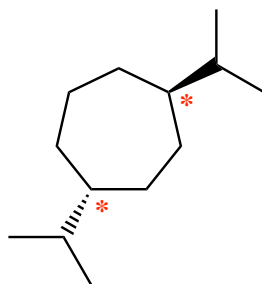
trans-1,4-diisopropylcycloheptane
trans-1,4-di(1-methylethyl)cycloheptane
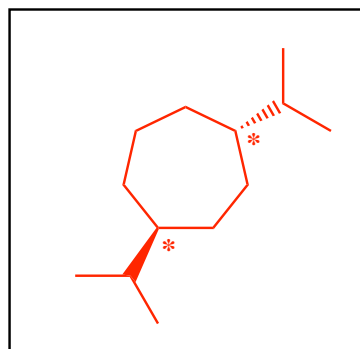
Is the molecule chiral? __Yes__ If you answered yes, then in the box provided, draw the enantiomer of the above structure. If you answered "no" leave the box blank.

4. (5pts 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) 3,3-diethyl-6-methyl-5-(1-methylpropyl)nonane
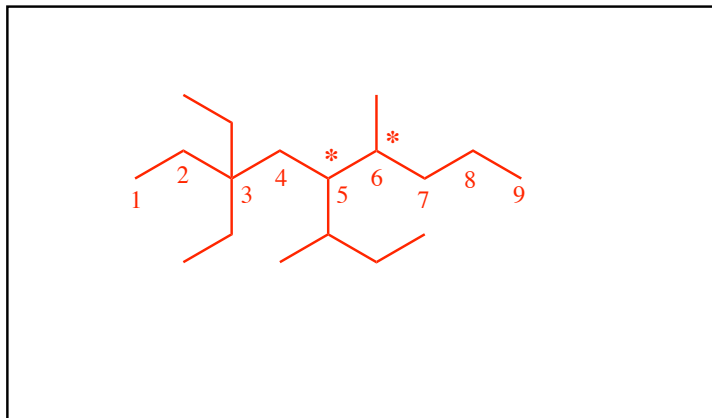
B) *cis*-1,3-di-*tert*-butylcyclohexane (Use wedges and dashes to indicate the appropriate stereochemistry at all chiral centers)

same structure, it is meso
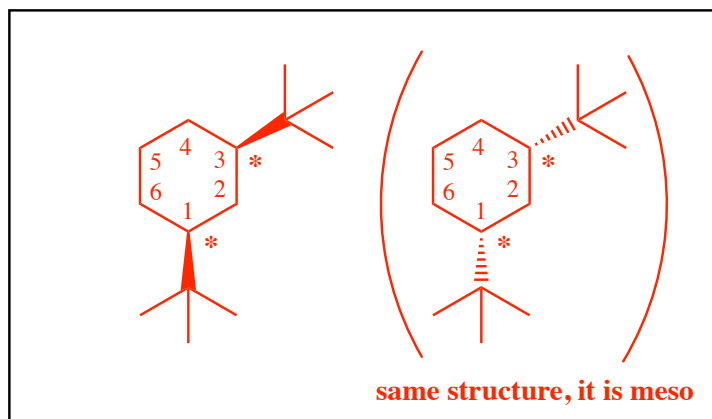
C) *(S)*-3-Ethyl-5-isopropyloctane (Use wedges and dashes to indicate the appropriate stereochemistry at all chiral centers)
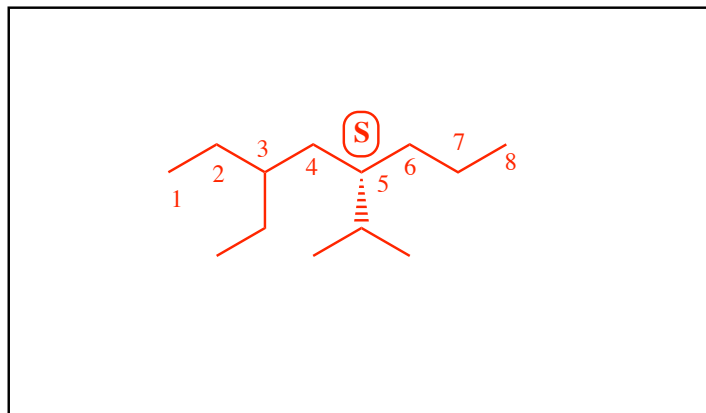
5. (17 pts) The following molecules are best represented as the hybrid of contributing structures. **Draw the second important contributing structure** in the space provided, including all lone pairs and formal charges. **For the structure on the left, use arrows to indicate the movement of electrons 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.
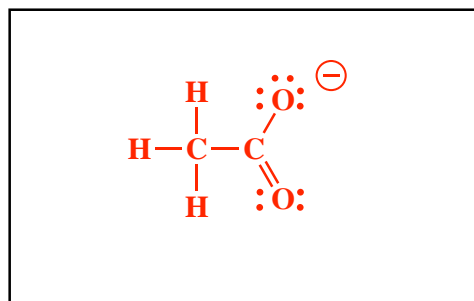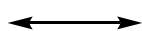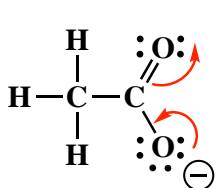
B.
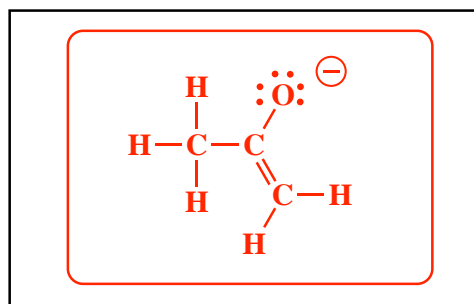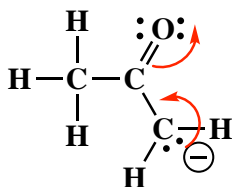
C.
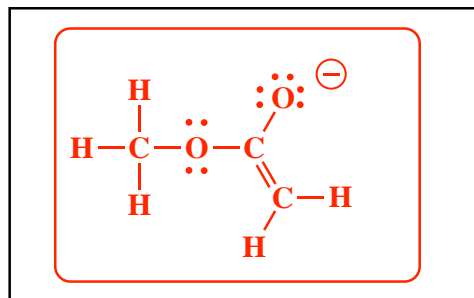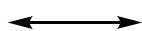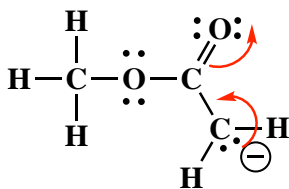
6. (10 pts each) The following molecules are best represented as the hybrid of three contributing structures. **Draw the other two most important contributing structures** in the spaces provided, including all lone pairs and formal charges. **Use arrows on Structure 1 to indicate the movement of electrons to go from Structure 1 to your Structure 2, then put arrows on your Structure 2 to indicate the movement of electrons to go from your Structure 2 to your Structure 3.** There is **no need to draw any circles around any of these contributing structures**. You might want to read these directions again to make sure you know what we want.

Structure 2   **Structure 3**

Structure 1

A.

B.
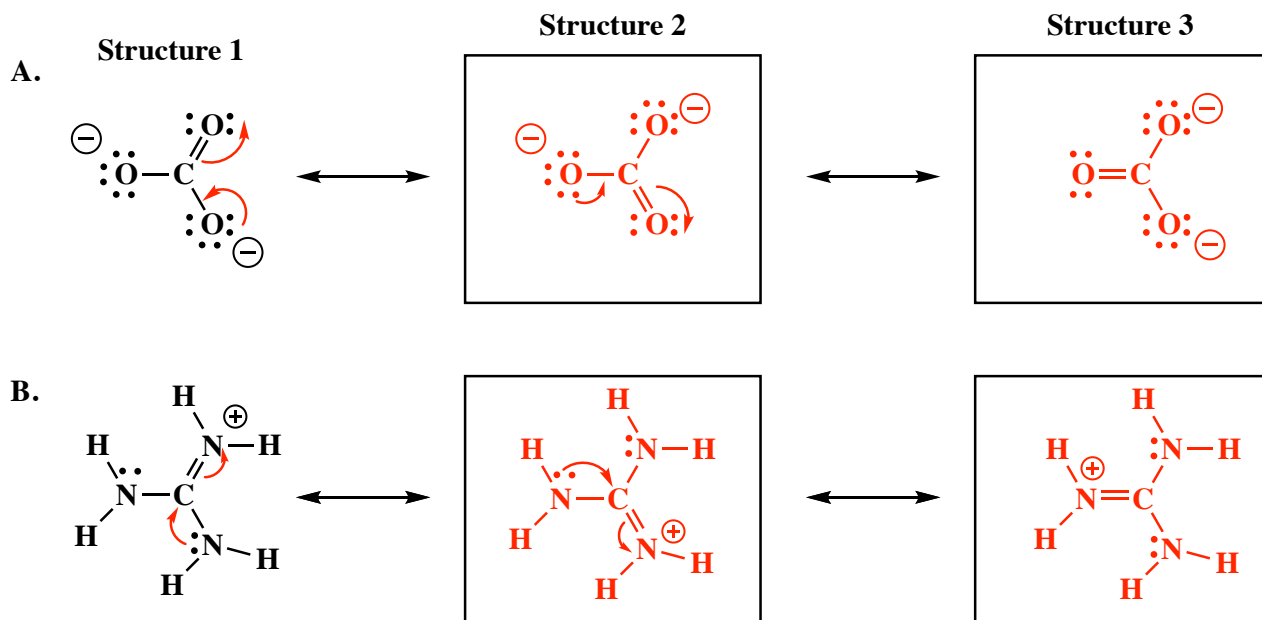
7. (10 pts) I told you this would be here. The following amide molecule is best represented as the hybrid of three contributing structures. **Draw the other two most important contributing structures** in the spaces provided, including all lone pairs and formal charges. **Use arrows on Structure 1 to indicate the movement of electrons to go from Structure 1 to your Structure 2, then put arrows on your Structure 2 to indicate the movement of electrons to go from your Structure 2 to your Structure 3.** 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.

Structure 2   **Structure 3**

Structure 1

8. (2 pts each) Fill in each blank with the word or words that best completes the sentences.

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

The electron density in molecules can be described mathematically by adding the wave functions of

all the atomic orbitals for all the atoms in the entire molecule, an approach referred to as

_____molecular_____   _____orbital_____ theory.

The wave functions for the valence atomic orbitals on each atom can be added together first, a

process referred to as _____hybridization_____ , before looking for overlap with orbitals from

other atoms. This approach is called _____valence_____   _____bond_____ theory.

You need to be able to think about all _____sigma_____ bonding in molecules as being

derived from the overlap of _____hybridized_____ orbitals and all pi bonding as being derived from

overlap of unhybridized _____2p_____ orbitals.

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-ways), parallel _____2p_____ orbitals are needed on ALL of the adjacent

atoms involved, explaining why ALL of these atoms must be _____sp^2_____(or _____sp_____)

hybridized and why these systems are planar.

Breaking News: A new species of tiny crocodile was just discovered in a chemistry laboratory.

Latin Name: (3Z,4aZ,6Z,11aZ,13Z,14Z)-3,8,10,15-tetra-*tert*-butyl-9-heptyl-1a,1b,1c,2a,15a,16a,16b,16c -octahydro-1*H*,9*H*-cyclohepta[9,10]octaleno[3,4-*b*]cyclopropa[3',4']cyclobuta[1',2':3,4]cyclobuta[1,2- *e*][1,4]dioxine

9. (1 pt each) In the boxes provided, write the hybridization state (i.e. *sp³*, etc.)of the atoms indicated by the arrow.

Imatinib (A next generation cancer drug targeting a kinase)

sp³

sp²

sp²

sp³

sp²

sp²

sp²

sp³

sp²

sp³

sp³

sp³

Allegra (Antihistamine)

sp

sp³

sp³

sp²

sp³

sp²

sp²

sp³

Nutrasweet

sp²

sp³

10. (2 pts each) Describe each bond indicated with an arrow as the overlap of orbitals. For example, an answer might be $\sigma_{\text{Csp}^3\text{-Csp}^3}$.

Nutrasweet

$\sigma_{\text{Nsp}^2\text{-Csp}^3}$

$\sigma_{\text{Csp}^2\text{-Csp}^3}$

$\sigma_{\text{Csp}^2\text{-Csp}^3}$

$\sigma_{\text{Csp}^2\text{-Osp}^2}$

$\pi_{\text{C2p-O2p}}$

$\sigma_{\text{Csp-Nsp}}$

$\sigma_{\text{Psp}^3\text{-Osp}^3}$

$\pi_{\text{C2p}_y\text{-N2p}_y}$

$\pi_{\text{C2p}_z\text{-N2p}_z}$
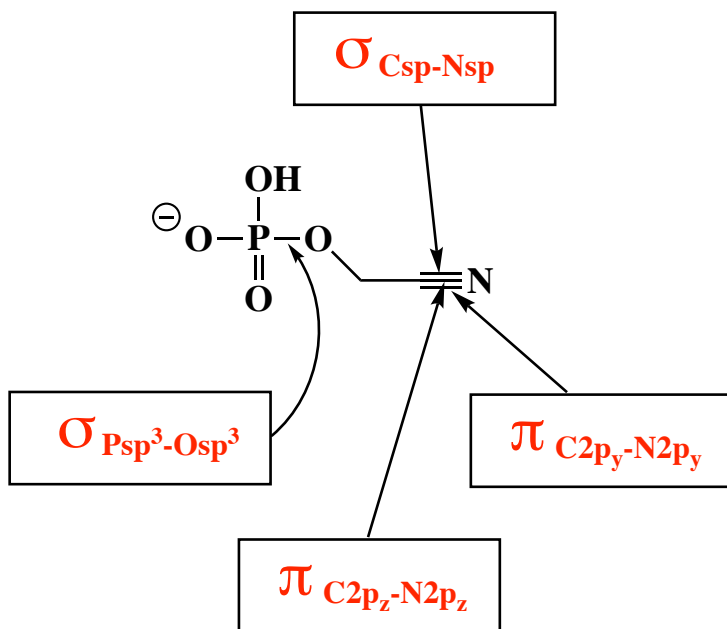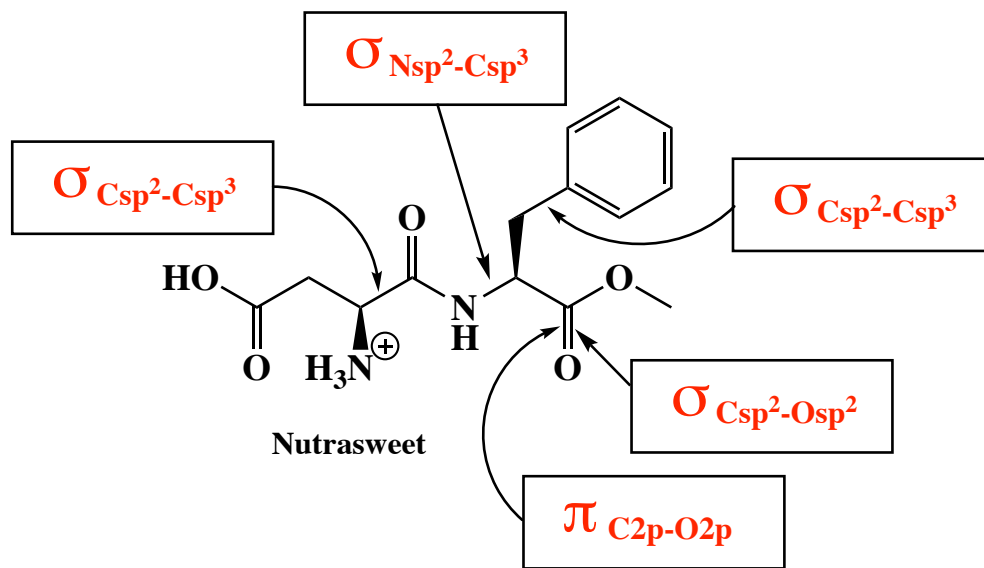
11. (8 pts) Circle any molecule that has an overall molecular dipole moment.
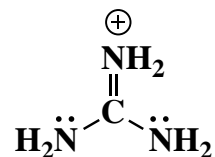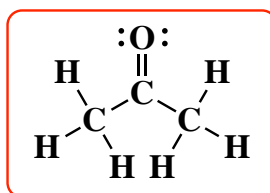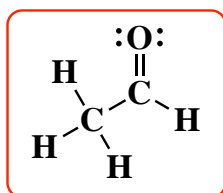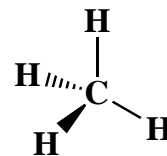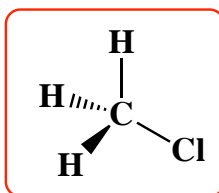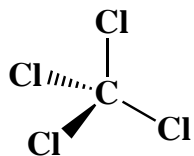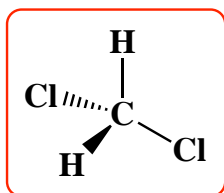
12. (15 pts) Circle all of the molecules that are chiral. Put an asterisk next to all chiral centers.
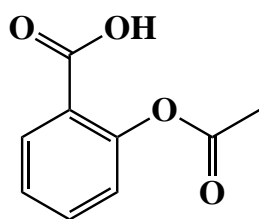
Aspirin
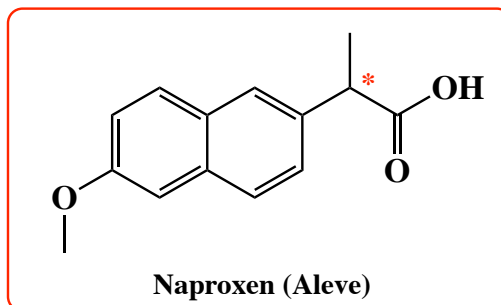
Naproxen (Aleve)
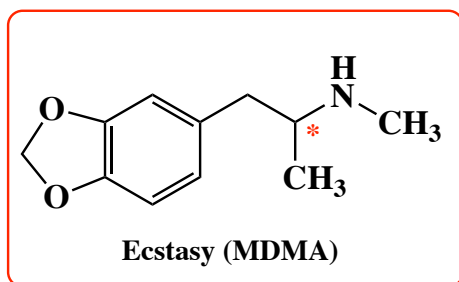
Ecstasy (MDMA)
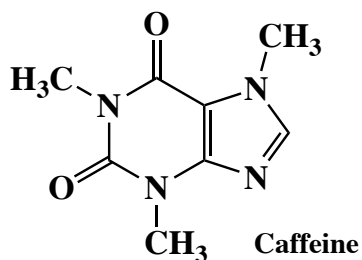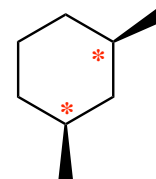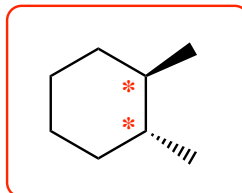
Caffeine
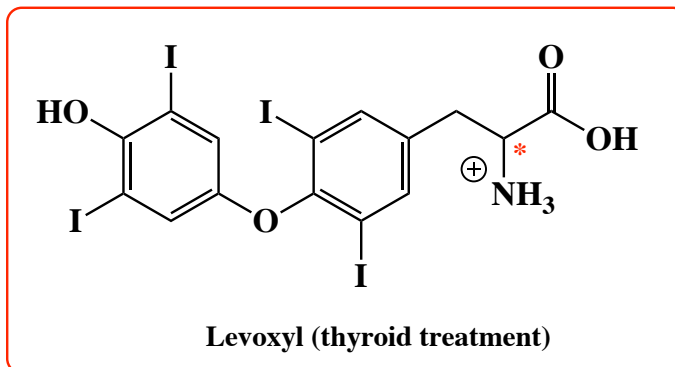
Levoxyl (thyroid treatment)

13. (2 pts each right answer) Below are three calculated pi orbitals for the amide molecule drawn.

A   B   C
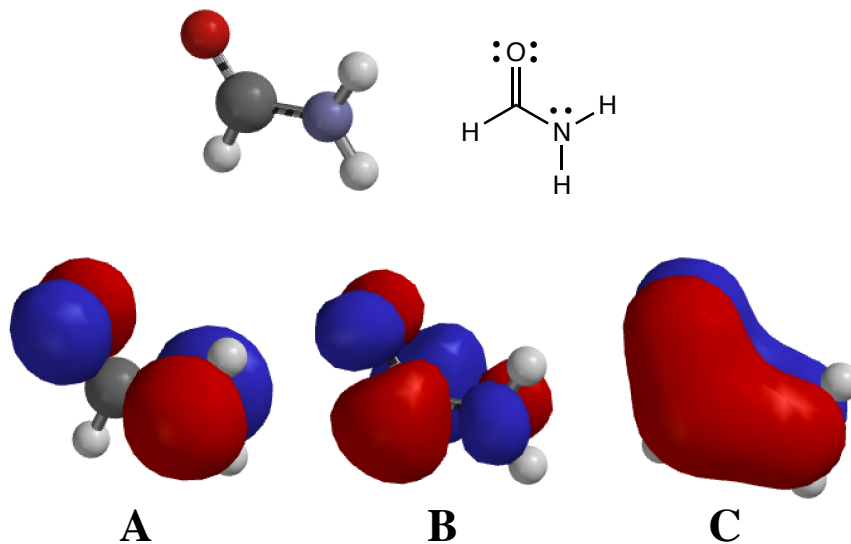
We do not expect that you can calculate these orbitals on your own, but you should have some idea about what they mean. Orbitals define an area of space in which electron density is located as well as an associated energy.

A. **Which of the three orbitals; A, B, or C is the HIGHEST in energy?** _____ **B**

B. **Which of the three orbitals; A, B, or C is the LOWEST in energy?** _____ **C**

C. **In this amide, how many electrons are located in these pi orbitals?** _____ **4**

D. **Write the letters of the orbitals that are filled with electron pairs** _____ **A, C**

E. **What is the hybridization state of the N atom in this amide?** _____ sp^2

F. **Write the letter of the one orbital that best explains the N atom hybridization state you answered in part E** _____ **C**

G. **Write the letter of the one orbital that best explains why the C-N bond of the amide has highly restricted bond rotation** _____ **C**

14. (20 pts) 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:
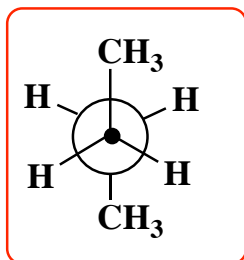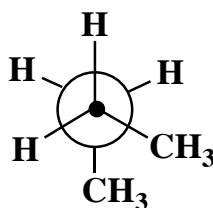
	Angle strain	Torsional strain	Steric strain
			X
		X	X
		X	
			X
	X	X	
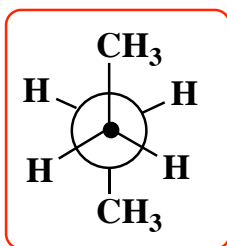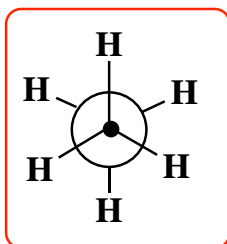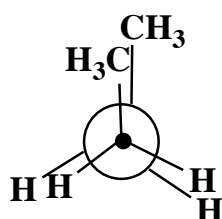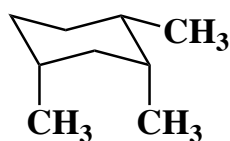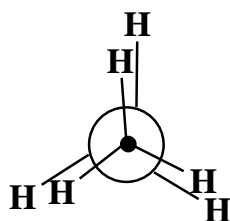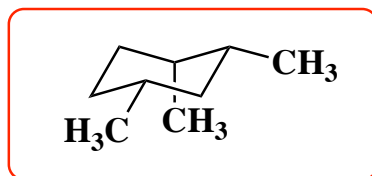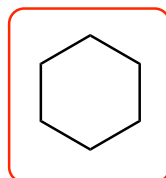
Think about this last one: Circle the molecule that will have the most stable *single* chair conformation.

		X
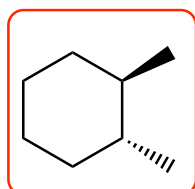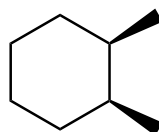
15. (5 pts) Fill in the Newman projection for the conformation of 1-chloro-2-methylpropane shown.
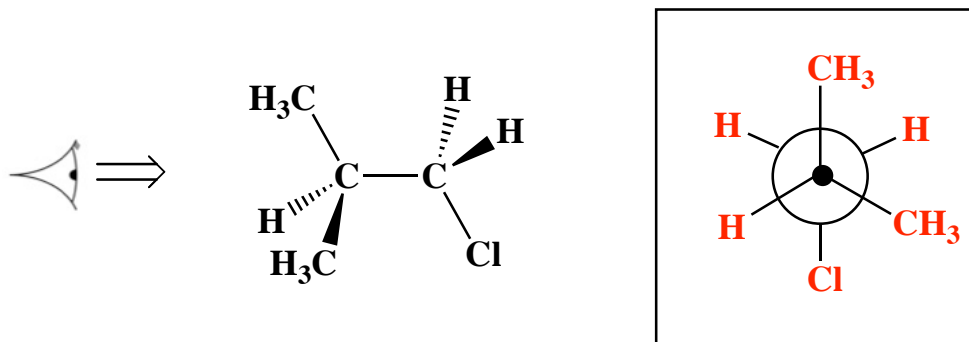
16. (5 pts) In the empty box draw the conformation of 1-chloro-2-methylpropane indicated by the Newman projection shown.
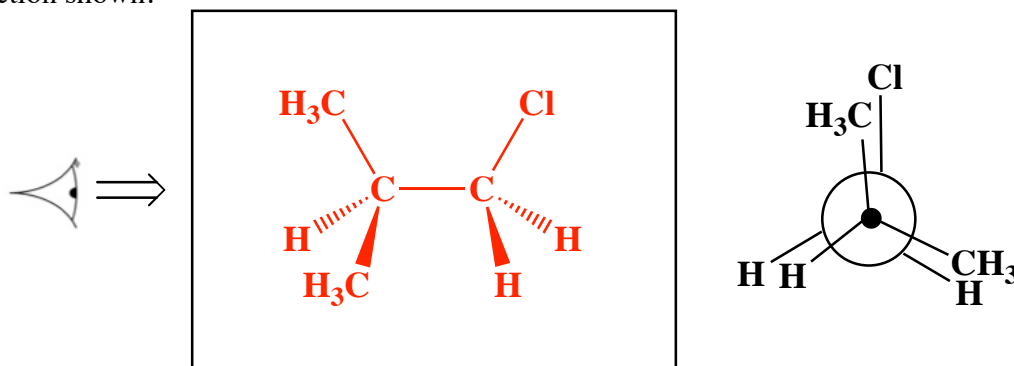
17. (7 pts) For the following cyclohexane derivative, draw the two alternative chair conformations. IF there is a difference in stability, draw a circle around the more stable conformation. If there is not any difference in stability, do not circle either chair form.
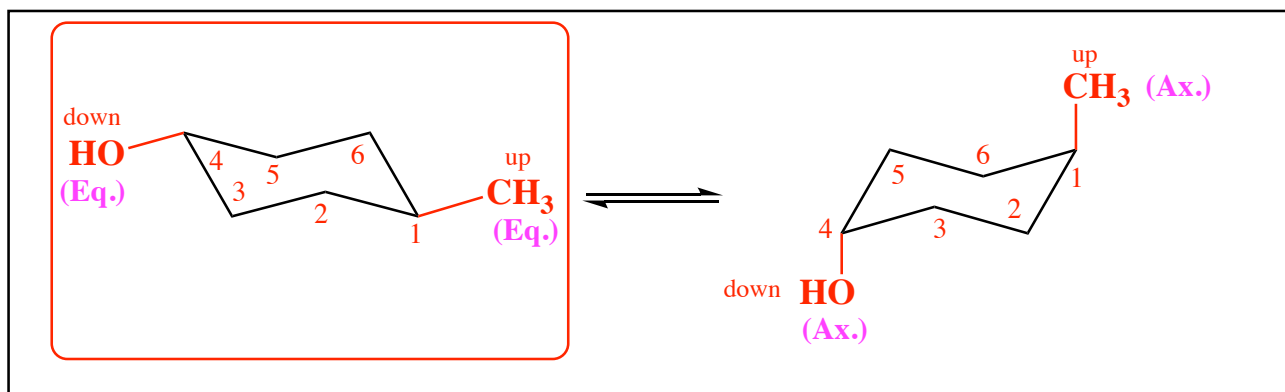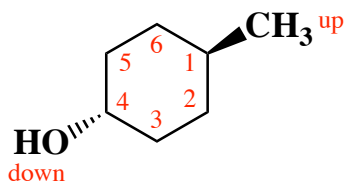
18. (7 pts) For the following cyclohexane derivative, draw the two alternative chair conformations. IF there is a difference in stability, draw a circle around the more stable conformation. If there is not any difference in stability, do not circle either chair form.
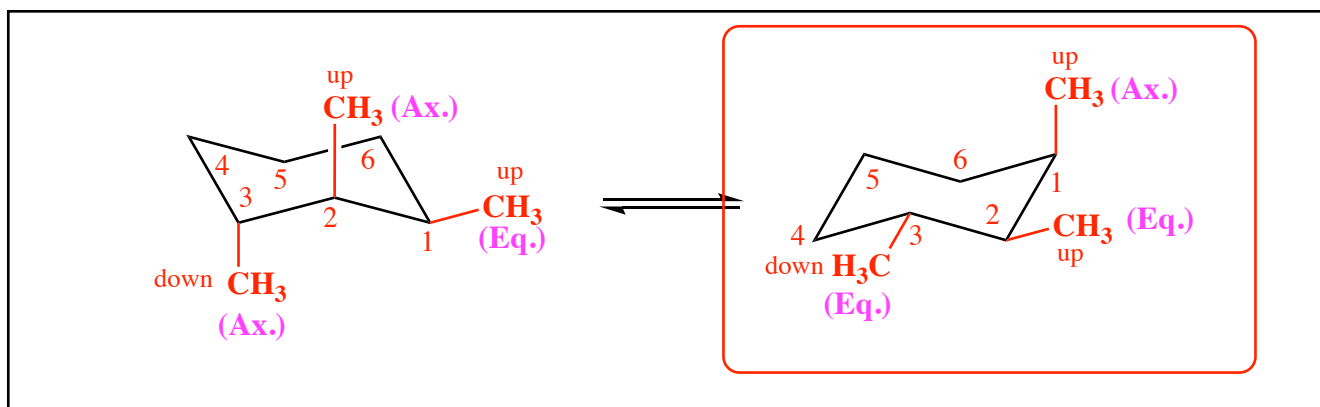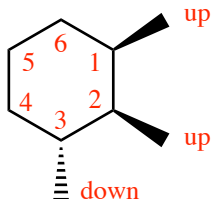
19. (2 pts each) Examine the following structures. For each molecule with a chiral center, assign the stereochemistry then write "R" or "S" as appropriate in the box provided below each structure. For all molecules that have no chiral centers, put an X in the box.
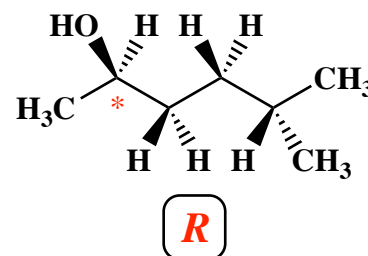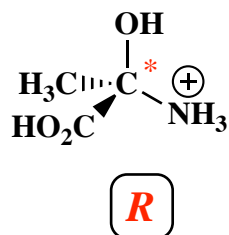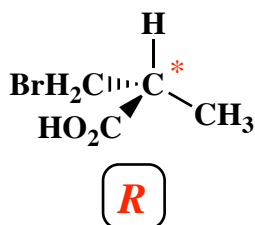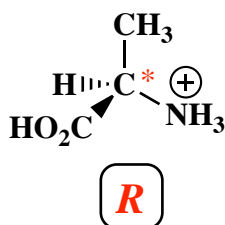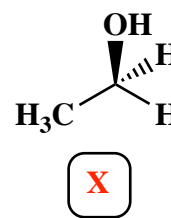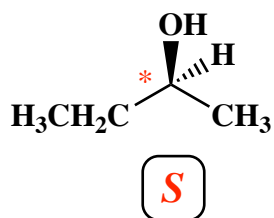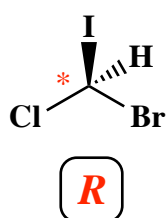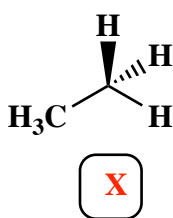
20. (20 pts) For each pair of molecules, on the line provided state the relationship between the two structures. Possible answers could be **enantiomers**, **diastereomers, consitutional isomers**, or **same molecule. Draw a circle around any meso compound.**
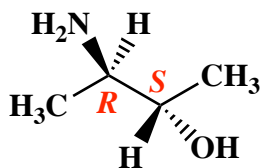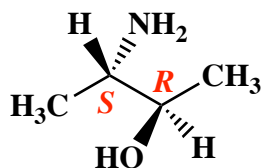
Relationship:
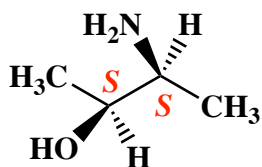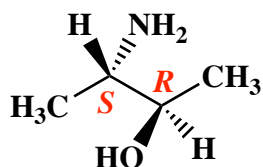
enantiomers

(2S,3S)-3-aminobutan-2-ol

diastereomers
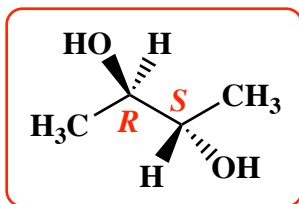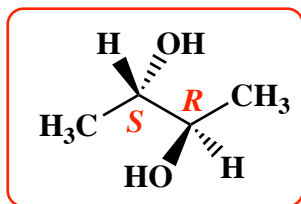
same molecule (both meso)
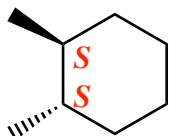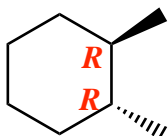
enantiomers

(No plane of symmetry so cannot be meso)
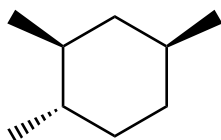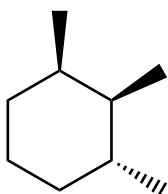
constitutional isomers

21. (16 pts total) Here is an "apply what you know" problem in the format of an MCAT style passage question. **In each case circle the single best answer.**

The boiling point for the sample of a pure compound depends primarily on both the attractive forces between molecules as well as overall molecular weight (MW). That is, the stronger the attraction between molecules and/or the larger the MW, the higher the boiling point. Consider the following set of molecules, listed with their respective boiling points and MW.

Molecule 1   **Molecule 2**   **Molecule 3**

MW = 86   MW = 86   MW = 86
boiling point 50°C   boiling point 62°C   boiling point 69°C
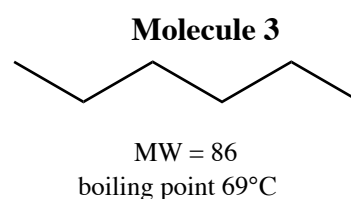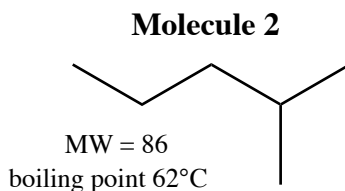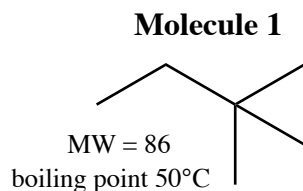
1. (4 pts) Compare the structures of Molecule 1, Molecule 2 and Molecule 3. Choose the following that best describes this set of molecules.

   A. They are best described as a set of constitutional isomers.
   B. They are best described as a set of conformational isomers.
   C. They are best described as a set of stereoisomers.
   D. They are best described as a set of configurational isomers.

2. (4 pts) Compare the boiling point for Molecule 1 with that of Molecule 2 and Molecule 3. What explains this trend?

   A. The attractive interactions between these alkanes are the result of transient induced dipoles.
   B. The extent of attraction is dependent on the amount of surface area available to interact with other molecules.
   C. Branching decreases surface area and simultaneously prevents close packing between molecules compared to straight chain alkanes.
   D. A, B and C

3. (4 pts) Based on what you know about boiling points, predict which of the following will have the lowest boiling point.

   A. 2,2-Dimethylpropane
   B. 2,2,3,3-Tetramethylbutane
   C. Pentane
   D. 2,2,3-Trimethylbutane

21. (continued)

Molecule 4   **Molecule 5**

MW = 106   MW = 86

Cl   OH

Molecule 6

MW = 106

Cl

Molecule 7

OH

MW = 86
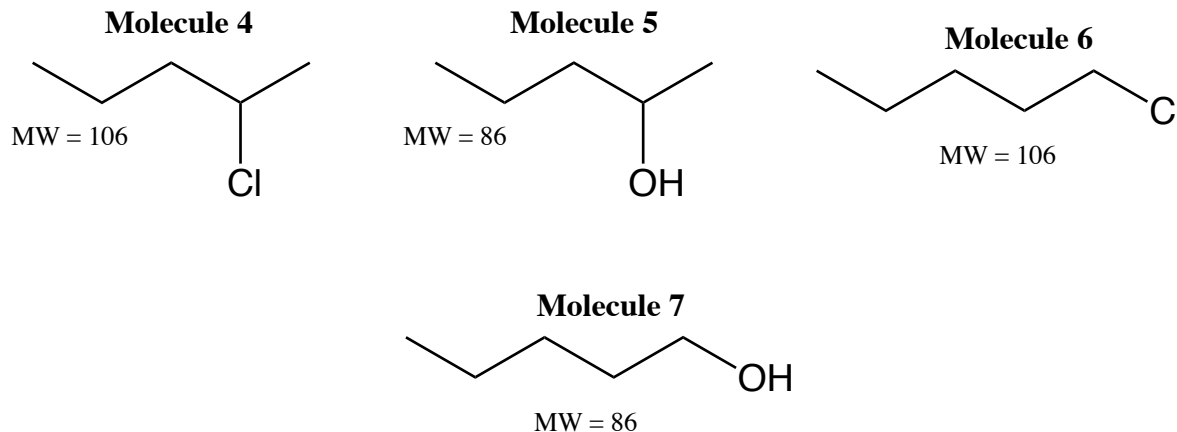
4. (4 pts) Based on what you now know about boiling points, which statement best describes the relative boiling points of Molecules 4-7?

A. The boiling point of Molecule 4 will be higher than that of Molecule 6, and the boiling point of Molecule 5 will be higher than that of Molecule 7.
B. The boiling point of Molecule 4 will be exactly equal to that of Molecule 6 because they have the same MW, and the boiling point of Molecule 5 will be the same as Molecule 7 because they have the same MW.
C. The boiling point of Molecule 4 will be lower than that of Molecule 6, and the boiling point of Molecule 5 will be lower than that of Molecule 7.
D. Yay, you are finished with the exam!!

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. 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!!!