CHEM 233, Fall 2019 Midterm #1 Ian R. Gould

COMPLETE THIS SECTION : Up to TWO POINTS will be removed for incorrect/missing information!

PRINTED **FIRST** NAME *Answer Key* _____ PRINTED **LAST** NAME _____

NAME OF the Person on your **LEFT** (or **Empty** or **Aisle**) _____

NAME OF the Person on your **RIGHT** (or **Empty** or **Aisle**) _____

Class you are REGISTERED FOR (**onground or hybrid**) _____

The room where the students world **normally** take the test for your class, e.g. LS A-191 for onground and PS H-152 for hybrid, etc., **do NOT write DRC here**) _____

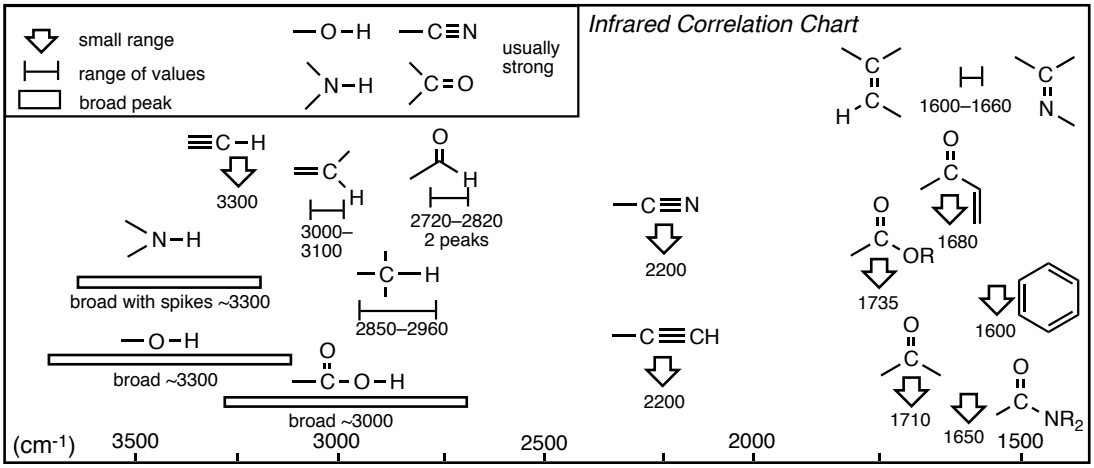
*****YOU ARE NOT ALLOWED TO TAKE SPARE COPIES OF THIS EXAM FROM THE TESTING ROOM*****

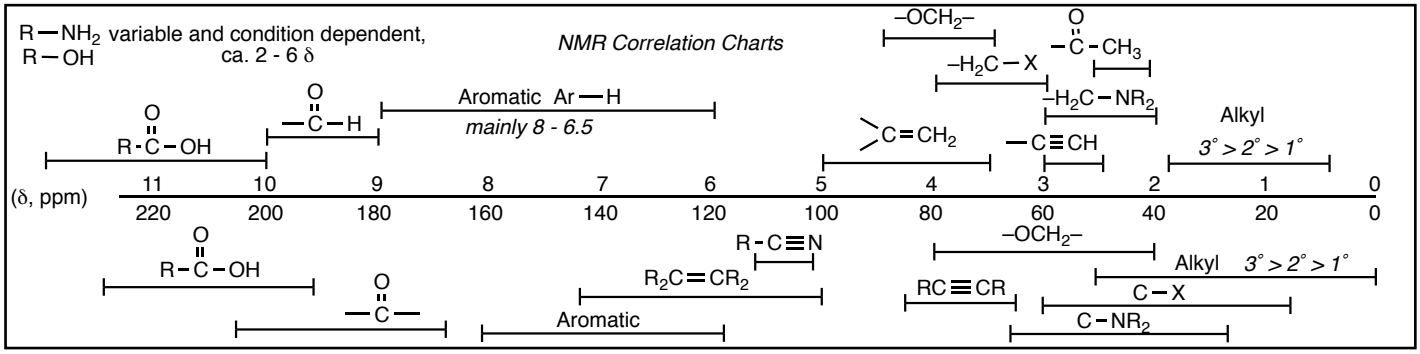
- *PRINT YOUR NAME ON EACH PAGE!*
- *READ THE DIRECTIONS CAREFULLY!*
- *USE BLANK PAGES AS SCRATCH PAPER*
  work on blank pages will not be graded...
- *WRITE CLEARLY!*
- *MOLECULAR MODELS ARE ALLOWED*
- *DO NOT USE RED INK*
- *DON'T CHEAT, USE COMMON SENSE!*

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn

Interaction Energies, kcal/mol

Eclipsing		Gauche	
H/H	~1.0	Me/Me	~0.9
H/Me	~1.4	Et/Me	~0.95
Me/Me	~2.6	i-Pr/Me	~1.1
Et/Et	~3.1	t-Bu/Me	~2.7





YOU MUST COMPLETE THIS PAGE WITH YOUR NAME
(EVEN THOUGH YOU ALREADY DID THIS ON THE COVER PAGE)
AND ALSO GIVE YOUR ASU OR POSTING ID NUMBER
WE NEED THIS NUMBER BECAUSE YOU WOULDN'T BELIEVE THE NUMBER OF STUDENTS WHOSE NAMES WE CAN'T READ!

PRINTED **FIRST** NAME ***Answer Key*** *PRINTED* **LAST** NAME _____ *ASU ID or Posting ID* _____

Points by question

1_____**/14**

2_____**/22**

3_____**/24**

4_____**/40**

5_____**/30**

6_____**/16**

7_____**/29**

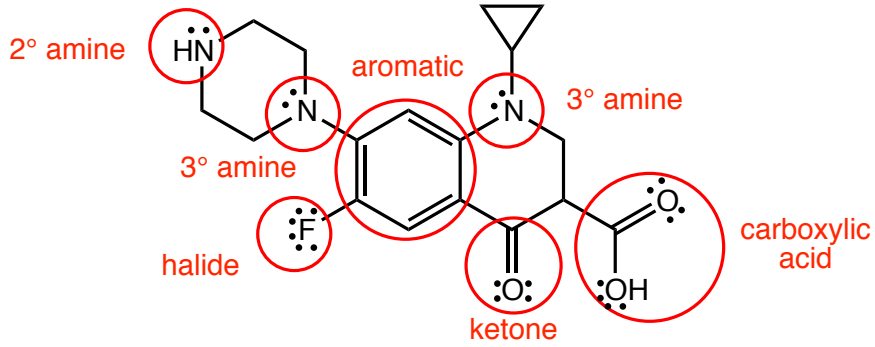
Points Removed for cover errors ____/2

Extra Credit_____/5

Total (incl Extra)_____/175+5

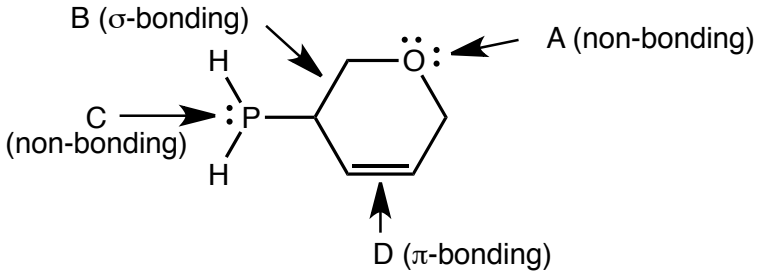
*****YOU ARE NOT ALLOWED TO TAKE SPARE COPIES OF THIS EXAM FROM THE TESTING ROOM*****

Question 1 (14 pts.) Circle and identify all functional groups in the following structure, ignore alkyl groups. Indicate any amines, amides or alcohols as primary, secondary or tertiary, as appropriate.



Ciprofloxacin, the only drug specifically approved by the FDA for treatment of inhalation anthrax exposure

Question 2 (22 pts.) Rank the pairs of electrons indicated, A, B, C and D in order of increasing energy. Give an explanation for your choice, most of the points are for the explanation, not the order.



B < **D** < **A** < **C**

lowest energy ____ highest energy

non-bonding electrons are higher in energy than bonding electrons, therefore **A** and **C** are highest in energy, phosphorus is larger and less electronegative than oxygen, **C** are thus highest

π-bonding electrons are higher in energy than σ-bonding electrons, thus **D** is next highest and **B** is lowest

Question 3 (24 pts.) For the structures **A** and **B** below:

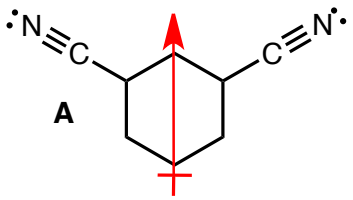
a) Indicate (in words, do not draw on the structures) the largest BOND DIPOLE moment(s) in each

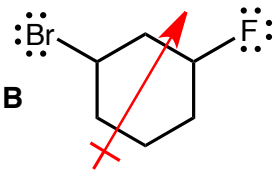
the largest bond dipole moment in A is that associated with the C-N triple bonds
the largest dipole moment in B is that associated with the C-F bond

b) Between these two largest bond dipole moments (the one from **A** and the one from **B**), which would be larger? Give a brief explanation.

the C-N triple bond dipole moment is larger because even though F is more electronegative than N, the electrons in the pi-bonds in the triple bond are highly polarizable

c) Draw the MOLECULAR DIPOLE MOMENTS ON TOP OF THE STRUCTURES. Your drawings do not need to illustrate the size of the dipole, only the direction. If there is no molecular dipole, indicate so. BRIEFLY explain which structure would have the larger MOLECULAR dipole moment.





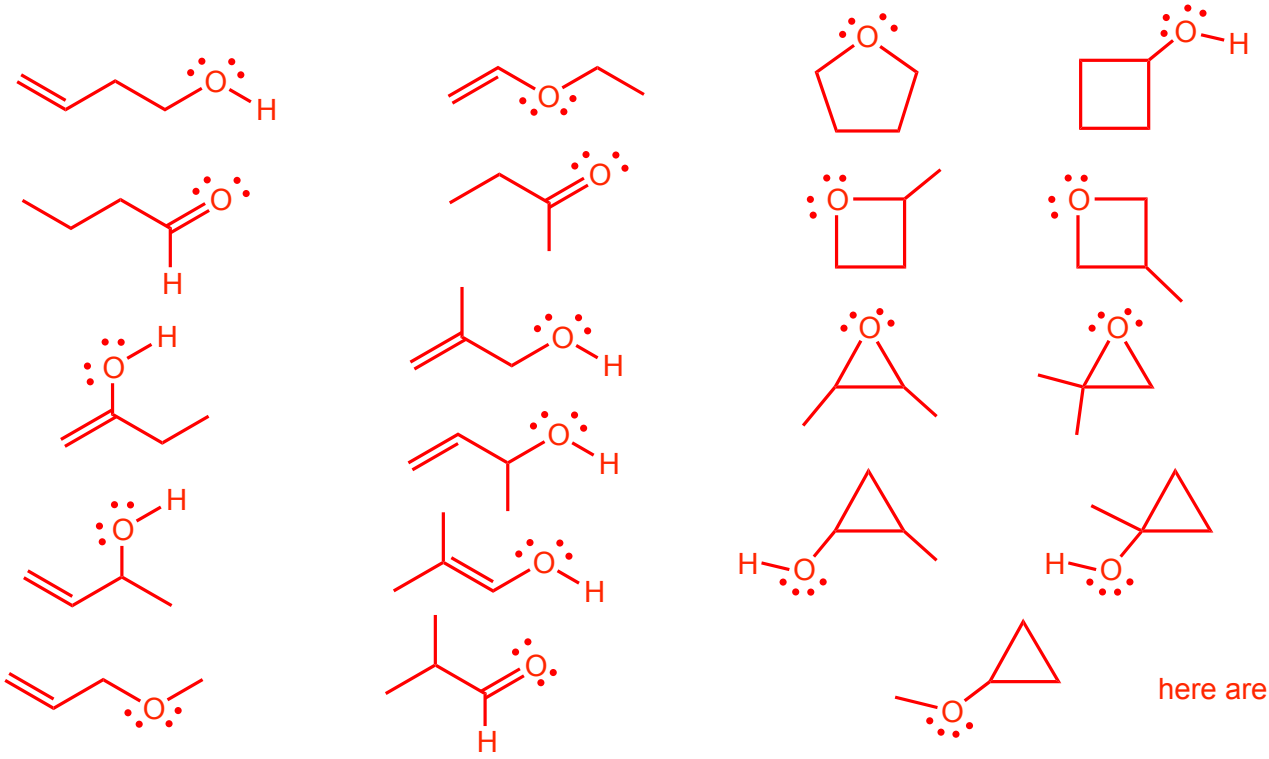
A has a larger MOLECULAR dipole moment because it has two larger bond dipole moments that add in (roughly) the same direction as the two smaller bond dipole moments in B

Question 4 (40 pts.) For the molecular formula C_4H_8O

a) Give the degrees of unsaturation

1 degree of unsaturation

b) Draw **EIGHT** structural isomers that obey the normal rules of valence for each atom. Include all non-bonding electrons. You can draw Lewis structures or line-angle structures (your choice). If you draw line-angle structures, don't forget to include the H atoms that are normally included as part of the functional groups.



here are a few.....

c) Draw **TWO PAIRS** of stereoisomers that obey the normal rules of valence for each atom. Include all non-bonding electrons. If you draw line-angle structures, don't forget to include the H atoms that are normally included as part of the functional groups.

DO NOT INCLUDE ANY STRUCTURES in part c) THAT WERE DRAWN AS PART OF YOUR ANSWER TO PART b) OF THIS QUESTION

here are four pairs

Extra Credit (5 pts.) BRIEFLY give ONE way in which anti-bonding orbitals are used by organic molecules

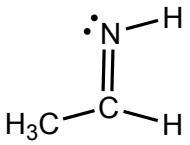
they accept electrons in chemical reactions AND they are where the electrons "go to" upon photochemical excitation

Question 5 (30 pts.) The structure shown is an imine, we will discuss the chemistry of these next semester. All non-bonding electrons are shown.

a) What is the hybridization of the nitrogen atom? sp2

b) What is the molecular geometry around the nitrogen atom? bent

c) What is the bond angle at the nitrogen atom? 120°



d) This next question asks if you know what hybridization really means. Give a list of ALL of the atomic orbitals that the oxygen uses in this molecule according to the hybridization model, AND, state exactly how the oxygen uses each one, e.g. the oxygen uses an sp3 orbital to make a p-bond to sulfur, it uses a p orbital to hold a non-bonding pair of electrons, (**these examples are nonsense, they are just to illustrate the FORMAT you should use to answer the question**)

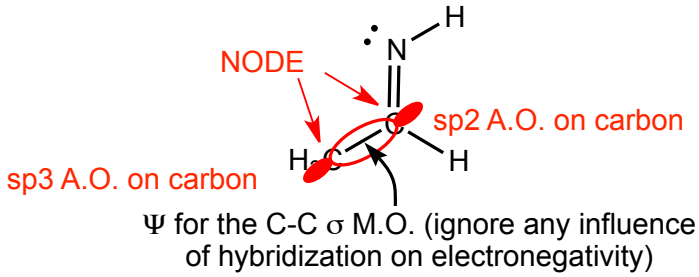
the nitrogen uses an sp2 hybridized atomic orbital to make a sigma-bond to carbon

the nitrogen uses an sp2 hybridized atomic orbital to make a sigma-bond to hydrogen

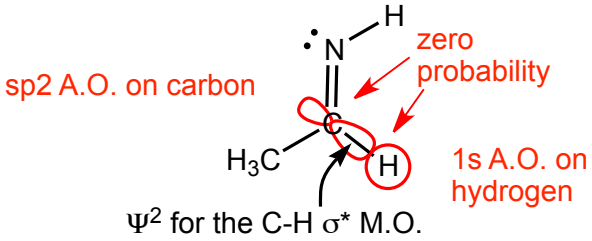
the nitrogen uses an sp2 hybridized atomic orbital to hold the non-bonding pair of electrons

the nitrogen uses a p atomic orbital to make a pi-bond to carbon

c) Directly ON TOP of the imine structures that are drawn below, draw a picture of the **Y OR Y^2 as requested**, for the indicated orbitals, AND, write down the atomic orbital or orbitals that you used to build these molecular orbitals, as appropriate. Clearly indicate the positions of all NODES for wavefunctions, and the positions in space where the probability of finding the electron is zero for wavefunctions squared.



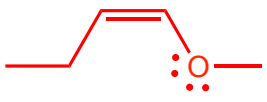
Ψ for the C-C σ M.O. (ignore any influence of hybridization on electronegativity)



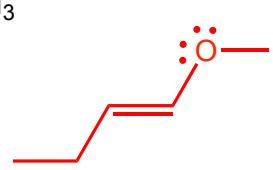
Ψ^2 for the C-H σ* M.O.

Question 6 (16 pts). Give line-angle structures for both stereoisomers of the following condensed formula. Do not forget to add all non-bonding electrons. Label each stereosiomer as either *cis-* or *trans-*.

$CH_3CH_2CHCHOCH_3$



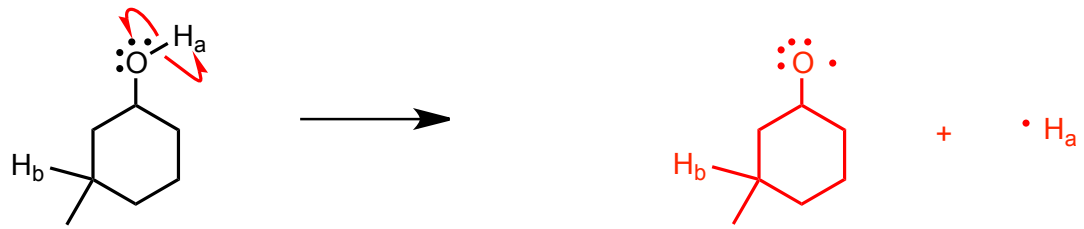
cis-



trans-

Question 7 (29 pts.)

a) For the O-Ha bond in the structure below, draw the curved arrow-pushing that describes homolytic bond cleavage and give the products of homolytic bond cleavage. Be sure to include all non-bonding electrons.



$\underline{H_b}$ < $\underline{H_a}$

smaller BDE larger BDE

b) Compare O-Ha bond and the C-Hb bond in the structure above. Which of these two bonds would have the larger bond dissociation energy? Give a brief explanation that includes the term "energy of the electrons" (the points are for the explanation, not choosing the bond).

oxygen is more electronegative than carbon, the electrons are lower in energy in the bond to oxygen, the O-Ha bond has the larger BDE

c) Draw an energy versus bond separation distance ($r_{Z\text{-}H}$) curve for homolysis of the two bonds O-Ha and O-Hb in the structure above, B on the same diagram using the axes provided below. Clearly indicate which curve corresponds to which bond cleavage and clearly indicate the two bond dissociation energies.