CHEM 233, Fall 2018 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**) _____

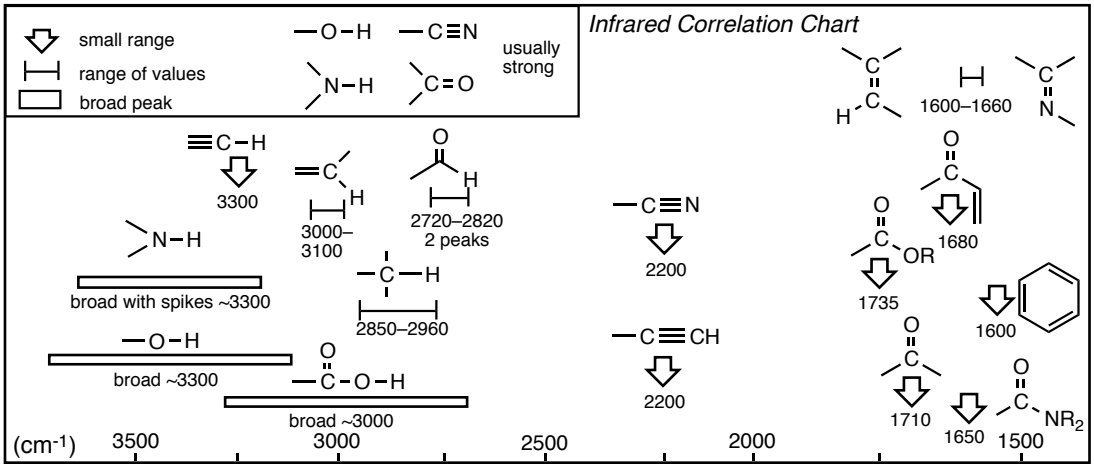
*****YOU ARE NOT ALLOWED TO TAKE SPARE COPIES OF THIS EXAM FROM THE TESTING ROOM*****

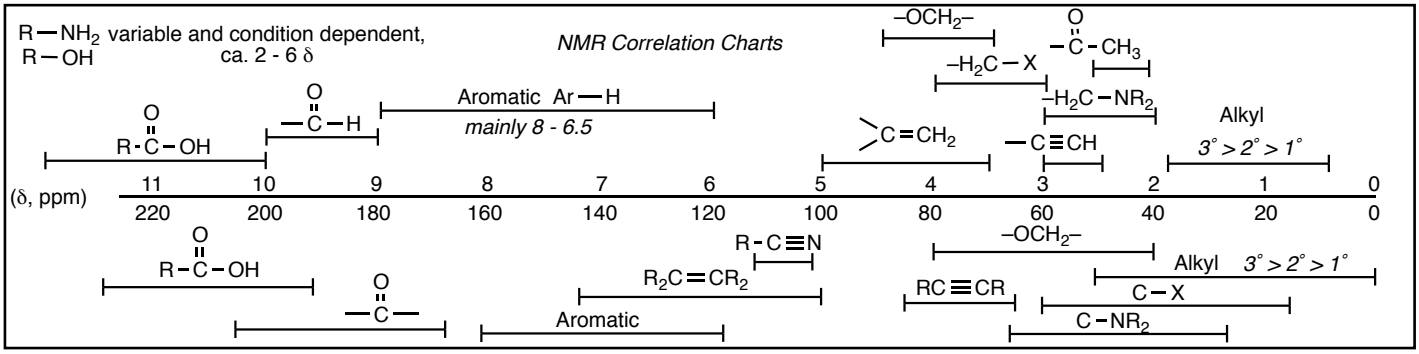
- *PRINT YOUR NAME ON EACH PAGE!*
- *READ THE DIRECTIONS CAREFULLY!*
- *USE BLANK PAGES AS SCRATCH PAPER*
  work on blank pages will not be graded...
- *WRITE CLEARLY!*
- *MOLECULAR MODELS ARE ALLOWED*
- *DO NOT USE RED INK*
- *DON'T CHEAT, USE COMMON SENSE!*

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_____/30

3_____/28

4_____/15

5_____/40

6_____/12

7_____/36

Points Removed for cover errors ____/2

Extra Credit_____/5

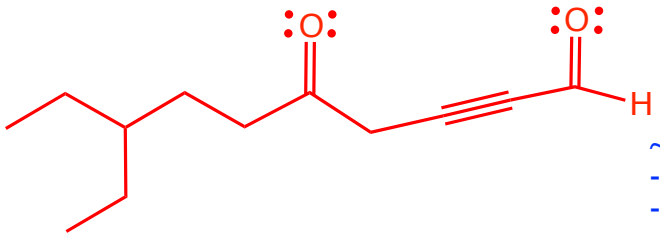
Total (incl Extra)_____/175+5

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

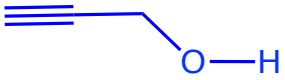
Question 1 (14 pts.)
a) Give a line-angle structure for the following condensed formula. Do not forget to add all non-bonding electrons where appropriate.

$(CH_3CH_2)_2CH(CH_2)_2COCH_2CCCHO$

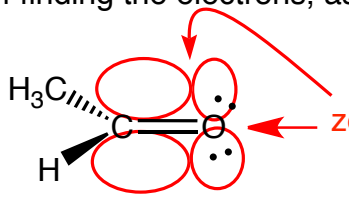
the graders do not get an absolute grading rubric for my tests, there are always too many possible ways to get partial credit in my exams, the guidelines in blue therefore are guidelines ONLY



~3 pts each for the functional groups
-2pts for incorrect alkyl groups
-3pts for this at the end:



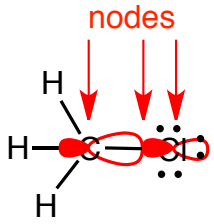
Question 2 (30 pts.) Directly ON TOP of the structures below
a) Draw a picture of the Ψ or Ψ^2 as requested, for the indicated orbitals
b) Clearly indicate the atomic orbital or orbitals that you used to construct the requested orbitals
c) For each drawing, clearly indicate the positions of any nodes, or locations of zero probability of finding the electrons, as appropriate to the question



Ψ^2 for the C-O $\pi*$ M.O.

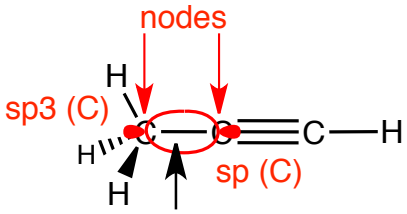
p A.O. (carbon)
p A.O. (oxygen)

incorrect sizes -2pts



sp3 A.O. (carbon)
p A.O. (chlorine)

Ψ for the C-Cl σ^* M.O.



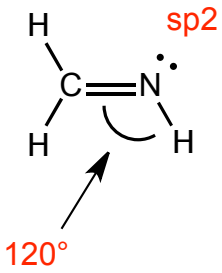
Ψ for the C–C σ M.O.

forgot A.O.s = -2pts
did the wrong question (wrong bond) = 7 pts maximum
did bonding instead of anti-bonding or vica versa 7pts max

Extra Credit (5 pts). One of the factors that contributes to the "stiffness" of the poly-peptide chains in proteins is.....

the wavefunctions	the geometrical isomers	**resonance**	the ester functional groups

Question 3 (28 pts.) For the structure shown on the right:
a) give the hybridization for the nitrogen atom
b) make a list (or make a small table) of the valence atomic orbitals formally associated with this nitrogen atom and give a brief description of how the nitrogen atom uses each orbital, e.g. the N has a p atomic orbital used to make a sigma bond to a chlorine (this is obviously nonesense, it is just to indicate how to answer the question)



too many options for a rubric, generally half correct = half points
there were 4 questions JUST LIKE THIS ONE on the problem set

the N has an sp2 hybrid A.O. containing one pair of non-bonding electrons

the N has an sp2 hybrid A.O. that is used to build the σ-bond to the hydrogen atom

the N uses an sp2 hybrid A.O. to build the σ-bond to carbon, which contains one of the pairs of electrons in the C=C double bond

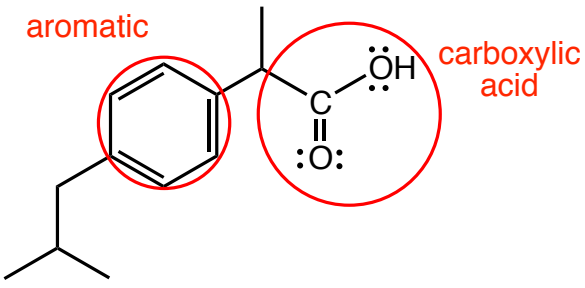
the N uses an unhybridized p A.O. to build the π-bond to carbon, which contains the second of the pairs of electrons in the C=N double bond

c) Give the approximate C-N-H bond angle indicated in the structure above with the arrow, assign the geometry around the nitrogen atom, AND, give a BRIEF explanation (**2-3 sentences MAX.**) for your choice of geometry that includes the terms "**energy of the electrons**", "**VSEPR**", "**electron domains**".

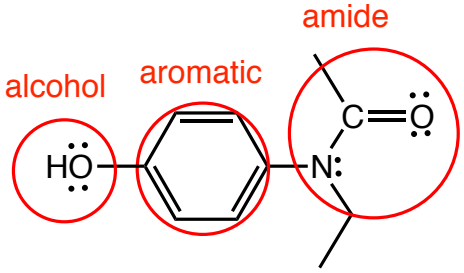
there are **3 domains of electrons** around the nitrogen, **VSEPR** requires a trigonal planar-like geometry to minimize the total **energy of the electrons**, **HOWEVER,** the nitrogen only has 2 atoms attached to it and the position of the non-bonding electrons cannot be determined with certainty, **the geometry can only be defined as bent**

students will probably give a less detailed explnation than this, which is OK, just so long as it is correct and includes the FOUR required items in bold above

Question 4 (15 pts.) Circle and identify all functional groups in the following structures, ignore alkyl groups. You do not ned to specify whether the functional groups are primary, secondary etc.



ibuprofen
the active ingredient in Motrin

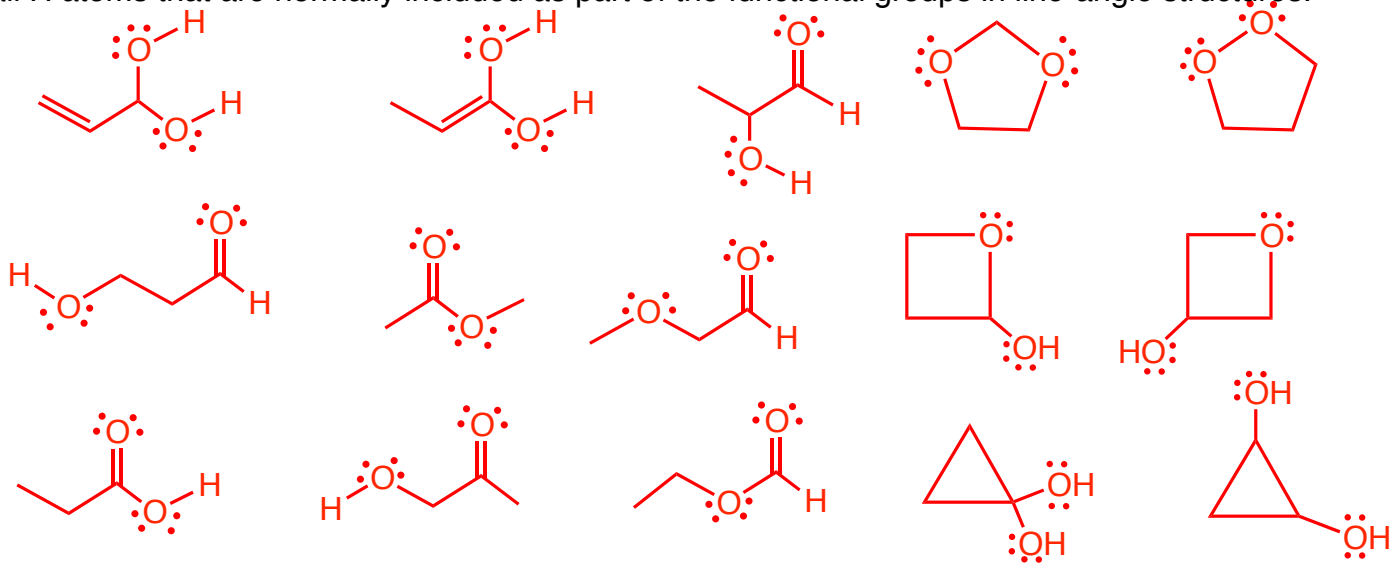


acetaminophen
the active ingredient in Tylenol

Question 5) (40 pts.) For the molecular formula $C_3H_6O_2$

a) Give the degrees of unsaturation 1 degree of unsaturation

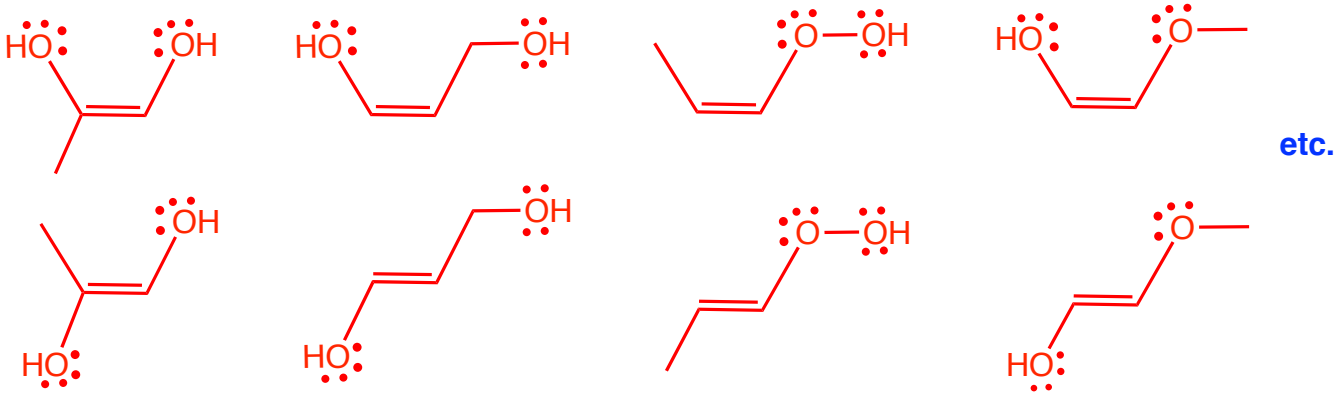
b) Draw **EIGHT** structural isomers for $C_3H_6O_2$ consist with normal valencies for each atom. Draw Lewis structures or line-angle structures (your choice) but include all non-bonding electrons. Include all H atoms that are normally included as part of the functional groups in line-angle structures.



there are MANY more than these!

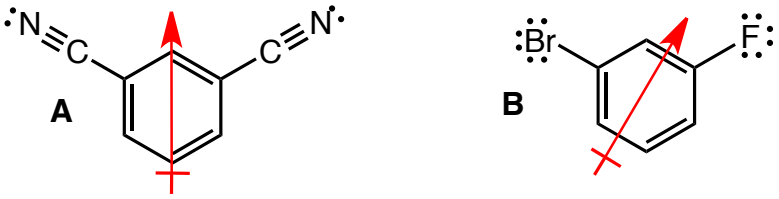
c) Draw **TWO PAIRS** of stereoisomers for $C_3H_6O_2$ that obey the normal rules of valence for each atom. Include all non-bonding electrons. You can draw Lewis structures or line-angle structures (your choice). If you draw line-angle structures, don't forget to include the H atoms that are normally included as part of the functional groups.

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



etc.

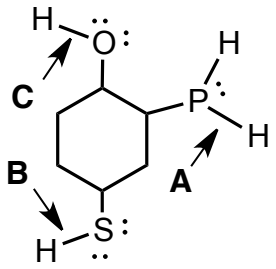
Question 6 (12 pts.) Draw the MOLECULAR DIPOLE MOMENTS ON TOP OF THE STRUCTURES. Your drawings do not need to illustrate the size of the dipole, only the direction. If there is no molecular dipole, indicate so. BRIEFLY explain which structure would have the larger MOLECULAR dipole moment.



Question 7 (36 pts.)

a) Rank the bonds indicated A, B and C in terms of increasing bond dissociation energy, give a brief explanation.

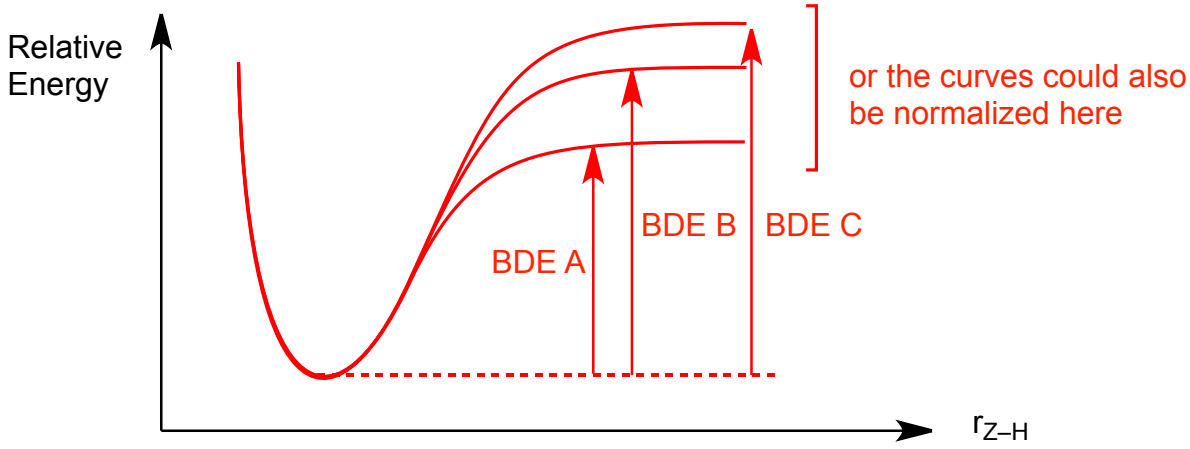
A (smallest BDE) < **B** < **C** (largest BDE)



O is both more electronegative and smaller than S, higher electronegativity and smaller atomic size decrease the energies of electrons in bonds, low energies of electrons in bonds make bonds harder to break (stronger bond), O-H is the strongest bond

P is less electronegative than either S or O, and P is larger than O, **lower electronegativity** and **larger atomic size** increase the energies of electrons in bonds, making a weaker bond, the P-H bond is the weakest

b) Draw an energy versus bond separation distance ($r_{Z\text{-}H}$) diagram for homolysis of the three bonds **A**, **B** and **C** above, all on the same diagram provided below. Clearly indicate which diagram refers to which bond cleavage and clearly indicate the three bond dissociation energies. You can normalize the energies in the bonds or in the cleavage products.



c) Treat homolytic bond dissociation as a simple chemical reaction. For BOND A below, add the curved arrows to the structure that illustrate bond-breaking and show the products of homolytic bond breaking (i.e. what you get after breaking the bond) on the "product side" of the reaction arrow below.