NAME _____

ID # _____

ORGANIC CHEMISTRY I (CHEM 2301)

9:30 – 10:20 am, July 1, 2014

Exam 1

If you want to pick your graded exam up tomorrow in class (in public), please check the box on the right: ☐

If you do not check the box, I will not bring your exam to class on Wednesday, and you will need to pick up your exam in private from Chemistry department staff in 115 Smith beginning Thursday, July 3rd. Exams that are not picked up within two weeks will be disposed of.

A periodic table is attached to the back of this exam as an aid. Otherwise, you are not permitted to use any other materials (including notes, books, or electronic devices of any kind).

Right now, write your name and student ID number at the top of this page. When the exam begins, please write your name at the top of the next page.

You may use pen or pencil. However, re-grades will be considered only for exams completed in pen.

Please write your answers in the boxes/spaces provided. If your answer is not in the appropriate space (say, for example, it's on the back of the page), draw us an arrow and/or note telling us where to look.

NAME _____

Scoring: 1. _____ / 6 4. _____ / 18

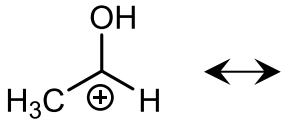
2. _____ / 15 5. _____ / 26

3. _____ / 17 6. _____ / 18

Total Score: _____ / 100

1. (6 pts) **Draw Lewis dash-bond structures** for two constitutional isomers that have molecular formula $\mathbf{C_3H_4O_2}$, and that have **no formal charges** on any atom. Draw all atoms, bonds, and lone pairs of electrons. In each box, draw just one explicit structure; do not draw multiple resonance structures, and do not draw a resonance hybrid that is an average of multiple structures.

2. (15 pts) For each of the molecules on the left, draw as many of the best Lewis dash-bond resonance structures as there are boxes to put them in. (Feel free to omit lone pairs and C-H's, or draw them—your choice.) Then, below each resonance structure, describe whether each would be a major or minor contributor. Finally, draw a consensus structure that illustrates partial charges and multiple bonds.



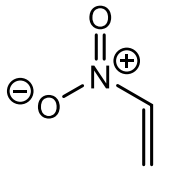
contribution:

(major/minor?)

resonance structure

contribution:

consensus structure



contribution:

(major/minor?)

resonance structure

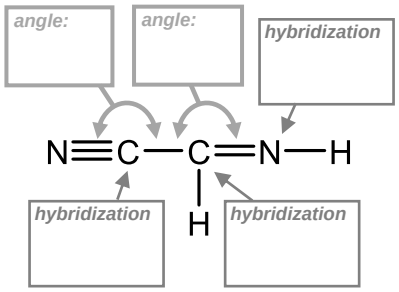
contribution:

resonance structure

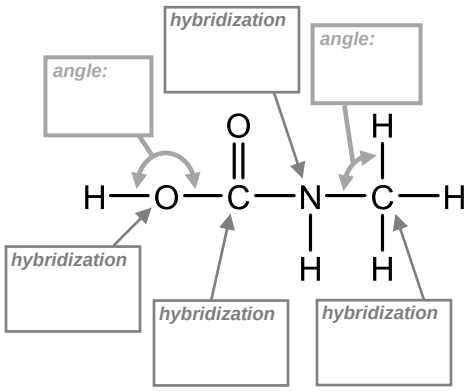
contribution:

3. (17 pts) For each of the Lewis structures drawn below, in the boxes provided:
   - Draw Lewis wedge/dashed-bond structures that illustrate the most stable three-dimensional structure of the molecule. Draw all atoms, but feel free to omit lone pairs.
   - In the boxes provided, write the hybridization state for any atom heavier than hydrogen.
   - In the boxes provided, give any bond angle indicated by curved arrows in the original Lewis structure.

consensus structure



wedge/dashed-bond (3D) structure



wedge/dashed-bond (3D) structure

4. (18 pts) For each of the sets of molecules below:
   - Using "electron pushing" (with double-barbed arrows), show how the molecules on the left would react in an acid-base reaction to transfer a proton from one to the other.
   - In the box on the right, draw the conjugate acid and base products of each reaction.
   - In the middle, draw an equilibrium arrow that shows whether you feel the acid-base equilibrium would lie on the left or the right.

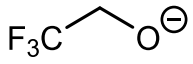
+

products

or

?

products



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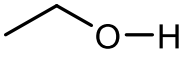
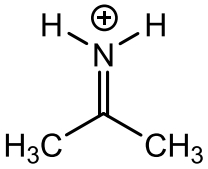


products



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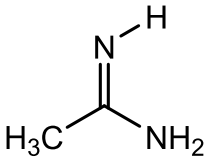
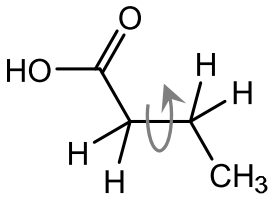


5. (26 pts) Butanoic acid (**BA**, drawn at right), is free to rotate about its C2-C3 bond, as shown.

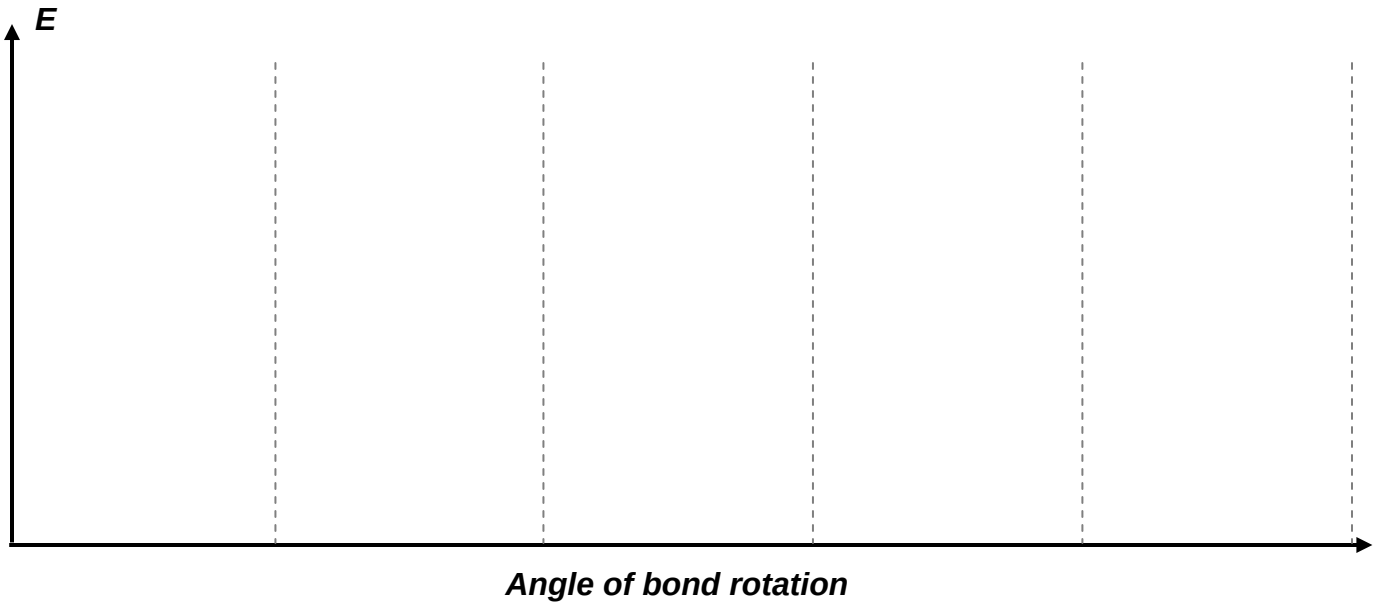


BA

(a) Starting from the Newman projection I've drawn below, draw four more Newman projections that would be encountered by twisting the central C-C bond in 60° steps. Then, indicate whether each Newman projection represents a ***gauche***, an ***anti***, or an ***eclipsed*** conformer by circling one answer.

gauche	***gauche***	***gauche***	***gauche***	***gauche***
or	*or*	*or*	*or*	*or*
anti	***anti***	***anti***	***anti***	***anti***
or	*or*	*or*	*or*	*or*
eclipsed	***eclipsed***	***eclipsed***	***eclipsed***	***eclipsed***
?	*?*	*?*	*?*	*?*

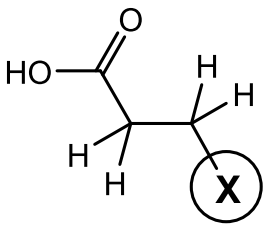
(b) What would be the relative energies of the five conformers above? In the space below, draw one continuous potential energy curve that illustrates these energies, in the same order as shown above.



(c) What is the name of the functional group in **BA** (the molecule from the previous page)?

(d) Within 1 pKa unit, what is the pK_a of **BA**?

(e) If **BA** had a group other than a $-CH_3$ on the right, how would that affect the energy difference between the "totally eclipsed" and anti conformers? For this problem, we'll define "ΔE" as the energy difference between the eclipsed and anti conformers, such that



$$\Delta E = [E(\textit{totally eclipsed}) - E(\textit{anti})].$$

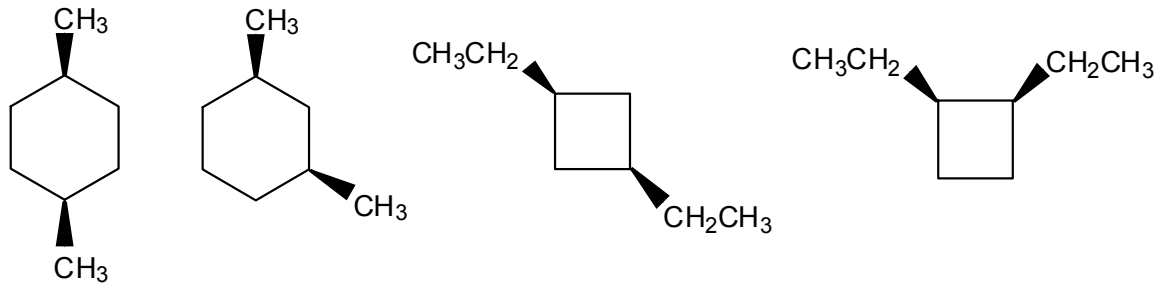
If **X** = -$C(CH_3)_3$ ("*tert*-butyl"), would

ΔE{**X** = -$C(CH_3)_3$} be ***greater than*** , ***less than*** *or* ***equal to*** ΔE{**BA**} ?

If **X** = -OH, would

ΔE{**X** = -OH} be ***greater than*** , ***less than*** *or* ***equal to*** ΔE{**BA**} ?

6. (18 pts) This problem deals with the following four isomers of C_8H_{16}:



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

(a) Are these cycloalkanes ***cis-*** or ***trans-*** substituted? (Circle one.)

(b) For each of the molecules **A** and **B**, draw the most stable chair conformation. Include all hydrogens on the cyclohexane ring, but you can abbreviate the methyl groups as "-CH_3".

most stable chair conformation for **A**	*most stable chair conformation for* **B**

(c) Which of the two cyclohexanes—**A** or **B**—would have the *least* stable chair conformation? What would it look like?

least stable chair conformation

(d) Which of these two molecules is more stable,

A or **B** ? (Circle one.)

(e) Each of the isomers **A**-**D** has its own heat of combustion (ΔH_c^0), which is the amount of energy given off when the molecule is burned to CO_2 and H_2O. Combustion is always exothermic, so ΔH_c^0 is always negative. In the boxes below, rank the molecules (**A**-**D**) in terms of their heats of combustion, from most exothermic to least exothermic.

most exothermic (most negative ΔH_c^0)					least exothermic (least negative ΔH_c^0)