1. (12 points) Give the relationship between the following pairs of structures. The possible relationships are the following:

- same compound
- structural isomers
- resonance structures
- stereo isomers
- not isomers (different molecular formula)

a. ![Structural. 1,2-dibromo vs 1,3-dibromo.](image)

1. Resonance: No atoms can move!
2. Stereo: same condensed formula
3. Structural: different condensed formula

b. ![Same. Bond rotation around single bonds is allowed.](image)

d. ![Stereo. Trans-cis. Double bond can't rotate.](image)

e. ![Same. Both are 4-methylnonane](image)

f. ![Resonance. Electrons and charge is repositioned, but no atoms moved.](image)

2. (8 points) Draw line-angle structures and names for 4 of the 5 structural isomers of \( \text{C}_6\text{H}_{14} \).

- ![6. hexane](image)
- ![5. 2-methylpentane](image)
- ![3-methylpentane](image)
- ![4. 2,3-dimethylbutane](image)
- ![2. 2,2-dimethylbutane](image)
- ![3. 2,3-dimethylbutane](image)

Alkane Acyclic: \( \text{C}_n\text{H}_{2n+2} \)
Alkane Cyclic: \( \text{C}_n\text{H}_{2n} \)
Beware of drawing same thing twice!
3. (10 Points)
a. For the above structure, what is the hybridization and approximate bond angles (109, 120, or 180) about:

   - C-2: sp2, ~120°, trig planar
   - C-4: sp2, ~120°
   - C-6: sp3, ~109°, tetrahedral
   - O-8: sp3, ~109°, tetrahedral

b. In the above structure, N-1 is actually found to have 120° bond angles. (This may seem unexpected to you at this point, but we’ll learn why later in the course.) What must be the hybridization of the nitrogen?

   - sp2: Hybridization, bond angle, and electron geometry are all interlocked. To know any one of them is to know the others.

4. (2 Points) Bond rotation around C6-C7 in the above structure has a 7 kcal/mol barrier, while rotation around the C4-C5 bond has a 70 kcal/mol barrier. Explain very briefly why it is so much harder to rotate the latter bond?

   - Single bond versus double bond. A double bond has overlapping p-orbitals. To rotate a double bond, the p-p overlap would be lost. The full pi-bond would need to break. By contrast, no bonds are broken when you rotate around a single bond.

5. (4 points) For each of the pairs listed, circle the one with the higher boiling point.

   a. 

   - H-bonding
   - Extra carbons, hydrophobic

6. (6 points) Write a Lewis structure and assign any non-zero formal charges.

   a. [CH₃NH₃⁺]

   b. CH₃CO₂Na

   c. CH₃CHO
7. (5 points) a) Draw the best resonance structure for anion A, and circle the resonance structure that would make the greater contribution to the resonance hybrid.

b. For the two resonance structures shown below, circle the resonance structure that would make the greater contribution to the resonance hybrid.

8. (6 points) Rank the acidity of the following molecules, 1 being most acidic, 4 being least acidic. Hint: draw the anions!

9. (6 points) Draw a line-angle picture for all of the atoms in the molecule \( \text{CH}_3\text{CH}_2\text{COCHClCH}_3 \), including the hydrogens. Use the hash-wedge convention to indicate atoms that are not in the plane of the paper.

10. (5 points) Rank the ring strain in the following, from 1(most) to 3 (least). Explain very briefly the differences in strain.

A: has large angle strain (60° angles, not 109° angles)
B: By taking on chair conformation, there is zero angle strain, and zero torsional (no eclipsing)
C: If it has ideal angles, then some eclipsing and torsional strain destabilizes it
11. (6 points) Which of the following are capable of cis-trans stereoisomerism? (Yes/No).
   
a. 3-ethyl-1,1-dimethylcyclopentane
   
   ![No, no cis/trans distinction]

   b. 3-pentene (name means a double bond is between carbons 3 and 4)
   
   ![Yes, cis/trans]

   c. 1,3-dimethylcyclohexane
   
   ![Yes, cis/trans]

12. (9 points) Identify the functional groups in the following molecules. (Do not include "alkane", since that is not "functional". And do not specify "cyclic".)

   a. \( \text{H}_2\text{N} - \text{CO}_2\text{H} \) ("GABA: brain neurotransmitter"
   
   Amine, Carboxylic Acid

   b. Testosterone
   
   Ketone, Alcohol, Alkene

   c. Cocaine
   
   Amine, Ester, Arene or aromatic
13. (5 points) Give the IUPAC name for the following compounds.

- **a.**
  - ![Structure](image1.png)
  - 1. Longest chain
  - 2. Alphabetize substituents
  - 3. Number from end near substituent

- **b.**
  - ![Structure](image2.png)
  - 1. cis/trans for di-subbed rings
  - 2. Alphabetize substituents
  - 3. Numbering
  - 4. Know isopropyl and t-butyl

- **4-ethyl-3,6-dimethyloctane**
- **cis-3-methyl-1-propylcyclobutane**

14. (8 points) a. Draw Newman projections for the totally eclipsed, the gauche, and the anti conformations of 2,5-dimethylhexane, relative to the C3-C4 bond. You may abbreviate the isopropyl groups attached to C3 and C4 as "i-Pr" for convenience.

- ![Newman Projections](image3.png)

b. Explain very briefly why the rotation barrier around the C3-C4 bond of 2,5-dimethylhexane is greater than the rotation barrier in butane.

15. (8 points) a.) Draw the two chair conformations of cis-3-methyl-1-isopropylcyclohexane. (You don't need to show the H's on carbons other than 1 and 3). For convenience, you may abbreviate methyl as "Me" and isopropyl as "iPr"

- ![Chair Conformations](image4.png)

b.) Circle the more stable conformation.

c) Would trans-3-methyl-1-isopropylcyclohexane be more stable or less stable than the cis isomer?

- ![Additional Diagram](image5.png)

1. Make sure you've really drawn "flipped" chairs
2. What's "ax" in one chair flip is "eq" in the other.
3. Process cis-trans
4. Draw in H's on substituted carbons (easier to see ax/eq).