Chem 14C Final Exam (Winter 2021)

Monday, March 15, 2021 6:14 PM

Chem 14C Final Exam...

Chem 14C Final Exam

Winter 2021, Dr. Amber Reilly

Monday, March 15 from 6:30 pm – 8:00 pm

Name: ______________________________

Student ID Number: ______________________________

General instructions:

Permitted materials during the exam: The textbook for our course, notes you have taken, and any of the materials on CCLE.

You are NOT permitted to use the internet during the assessment, except to access CCLE. You should not be doing any of the following: google searches, posting questions on an online forum, using NMR or chemical databases, using NMR prediction software, or any other online activities outside of our CCLE page. Use of these materials/resources constitutes academic misconduct and will be reported to the dean.

You are NOT permitted to work with others or receive aid from any other sources.

Please read each question carefully and write your answer neatly in the space provided. When you are finished, upload your completed exam to Gradescope.

You may use scrap paper, but it will not be graded. Please write your final answer in the boxes or space provided following each question.

GOOD LUCK!

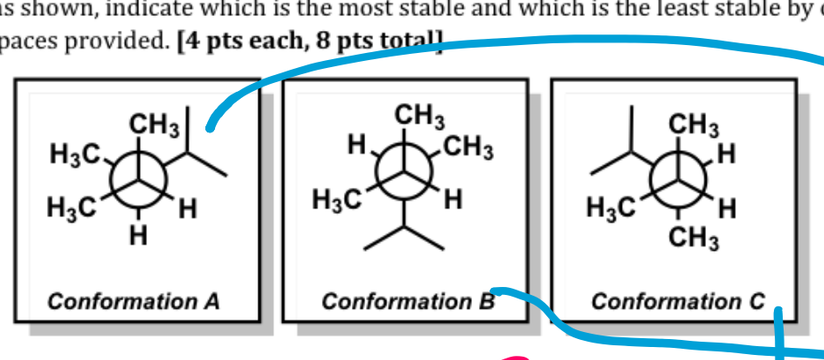
PLEASE SIGN YOUR NAME BELOW TO CONFIRM THE FOLLOWING STATEMENT

I hereby state that I have neither given aid to other people nor received aid from other people during this exam, including external websites or programs and have used only the permitted materials listed above. Sign below to confirm that this is true.

____

Sign Name

1) Shown below are three different conformations of 2,3,4-trimethylpentane using Newman projections. Among the conformations shown, indicate which is the most stable and which is the least stable by circling the letter A, B, or C in the spaces provided. **[4 pts each, 8 pts total]**



Most stable (circle one): A (B) C

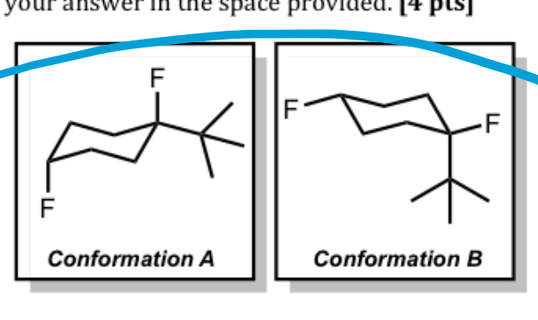
Least stable (circle one): A B (C)

CH_3,CH_3 gauche (bad)
CH_3,CH_3 gauche (bad) — 2 bad
CH_3, tBu gauche (worse) — 1 worse

CH_3,CH_3 gauche (bad) — 1 bad
CH_3, tBu gauche (worse) — 1 worse — most stable

CH_3,CH_3 gauche (bad) — 1 bad
CH_3, tBu gauche (worse)
CH_3, tBu gauche (worse) — 2 worse — least stable

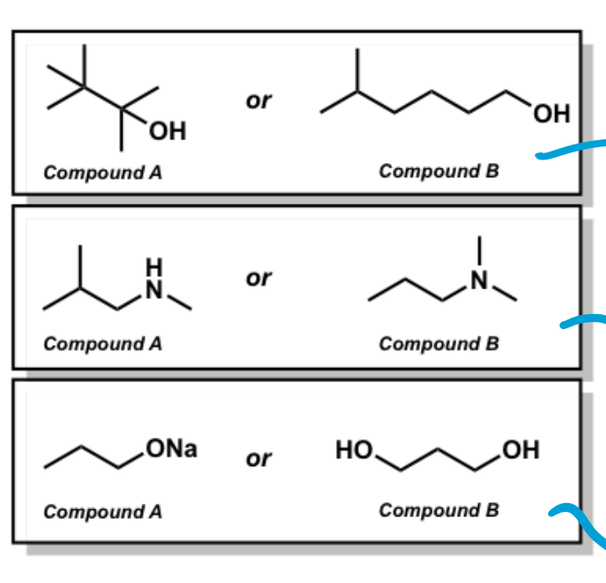
2) Shown below are two different chair conformations of 1-tert-butyl-1,4-difluorocyclohexane. A fluorine atom is slightly larger than a hydrogen atom. Indicate which conformation is more stable by circling the letter A or B in the space provided. Place your answer in the space provided. **[4 pts]**



More stable (circle one): (A) B

only slightly larger than H, while tBu is massive — much more stable in equatorial

3) For each pair of compounds below, indicate which compound is expected to have the higher boiling point (Compound A or Compound B in each pair) Circle your answer next to each box. **[3 pts each, 9 pts total]**

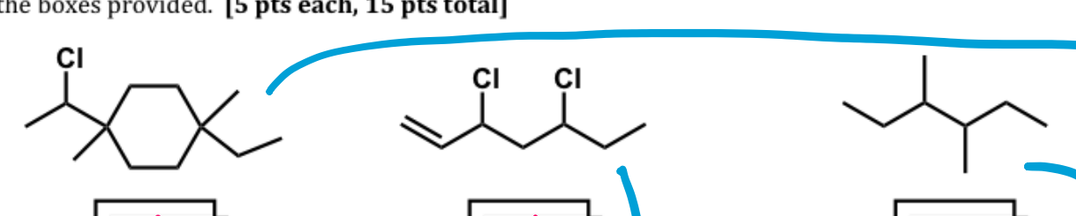


(Circle one): A (B) → both have H-bonding, D-D, and LDF, but the LDF is stronger for B due to larger surface area

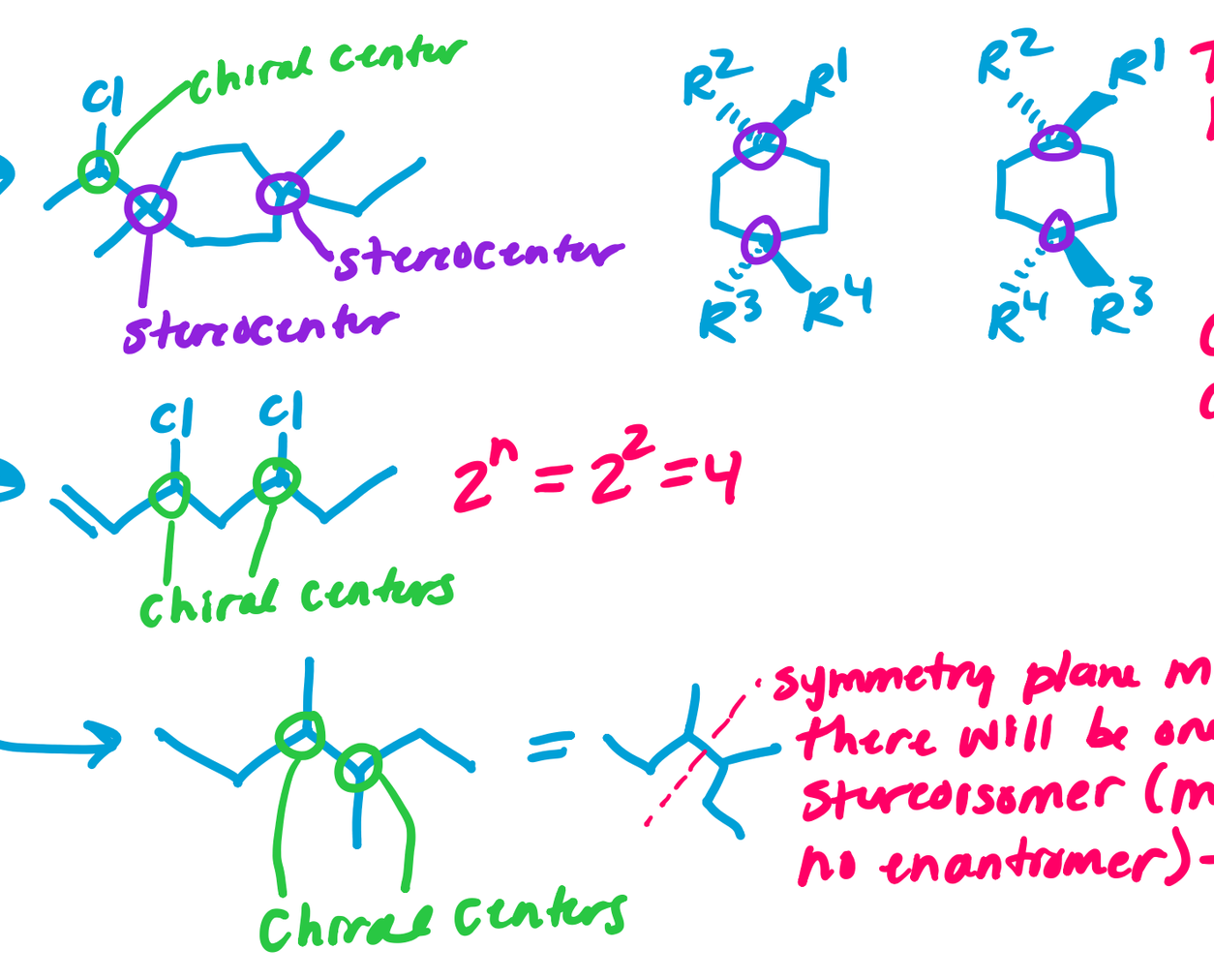
(Circle one): (A) B → A has H-bonding (NH), B does not (no NH)

(Circle one): (A) B → A is ionic, B is not

4) For each compound shown below, state **how many stereoisomers** there are for each. Place your answers in the boxes provided. **[5 pts each, 15 pts total]**



4 | 4 | 3



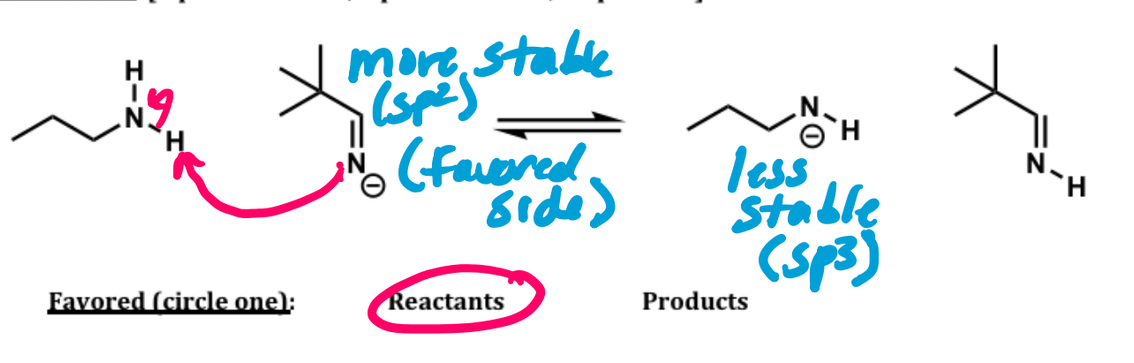
Two different cis/trans isomers due to stereocenters AND because there is also a chiral center, each cis/trans can have the chiral center as R or S → 4 total stereoisomers

In summary → cis, R; cis, S; trans, R; trans, S — 4 stereoisomers

$2^n = 2^2 = 4$

symmetry plane means there will be one meso stereoisomer (meso = achiral, so no enantiomer) → 1 less stereoisomer than 2^2 → $4-1=3$

5) Indicate which side of the equilibrium is favored for the reaction shown below by circling the word Reactants or Products below. Indicate the reason for your answer by ciricling one of the following: Atom (A), Resonance (R), Inductive Effect (I), or Orbital (O). If more than one effect contributes, select **ONLY** the effect that has the most significant impact. **Add arrows on the reactants side to show the mechanism of the reaction**. **[5 pts each circle, 2 pts for arrows, 12 pts total]**

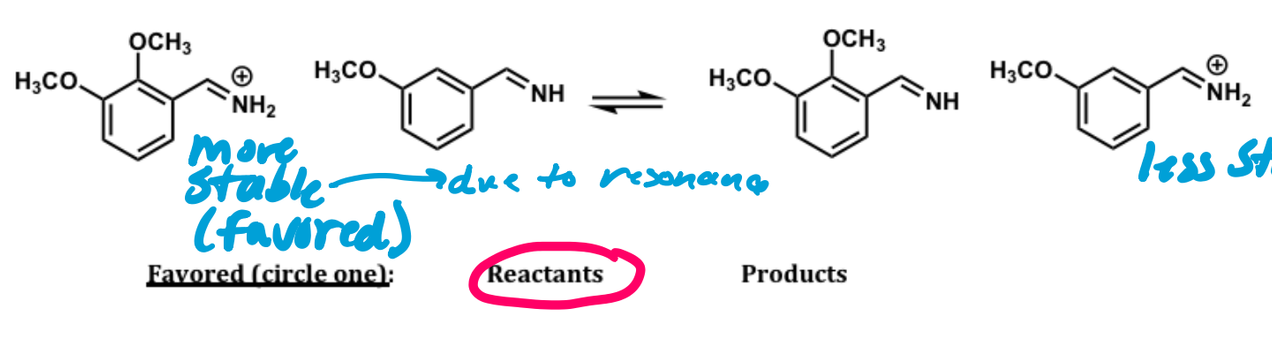


Favored (circle one): (Reactants) Products

Reason (circle one): A R I (O)

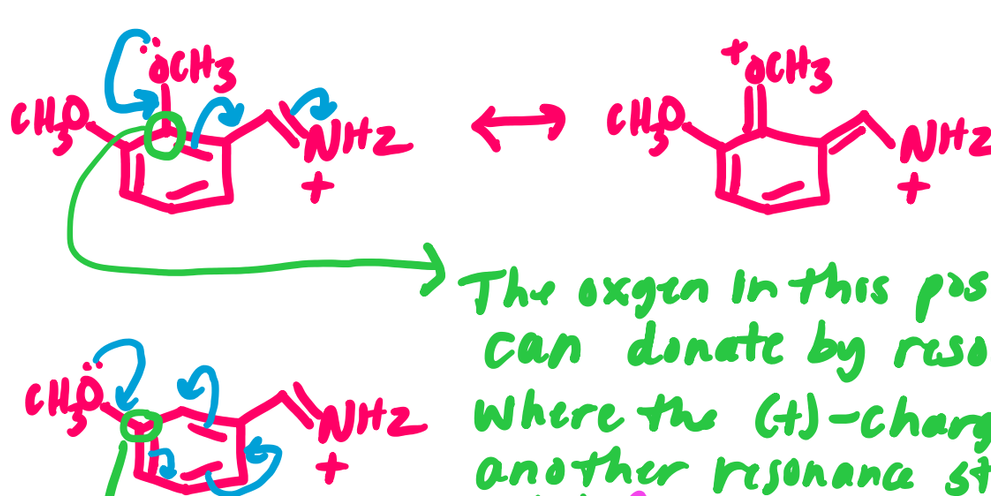
A → same
R → neither has resonance → If you thought the one w/ the double bond had resonance → complete octet, e^- can't be moved as shown → No resonance
I → both have no inductive effect
O → sp^2 vs sp^3 — more s-character = more stable base (weaker acid)

6) Indicate which side of the equilibrium is favored for the reaction shown below by by circling the word Reactants or Products. Indicate the reason for your answer by circling one of the following: Atom (A), Resonance (R), Inductive Effect (I), or Orbital (O). If more than one effect contributes, select **ONLY** the effect that has the most significant impact. **[5 pts each, 10 pts total]**



Favored (circle one): (Reactants) Products

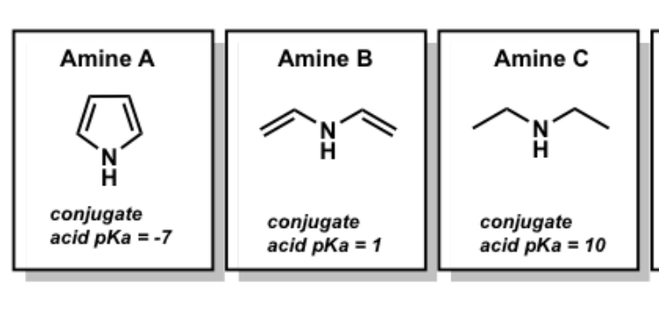
Reason (circle one): A (R) I O



The oxygen in this position can donate by resonance into the N where the (+)-charge is, which gives another resonance structure with complete octets (more stable than if O is unable to donate)

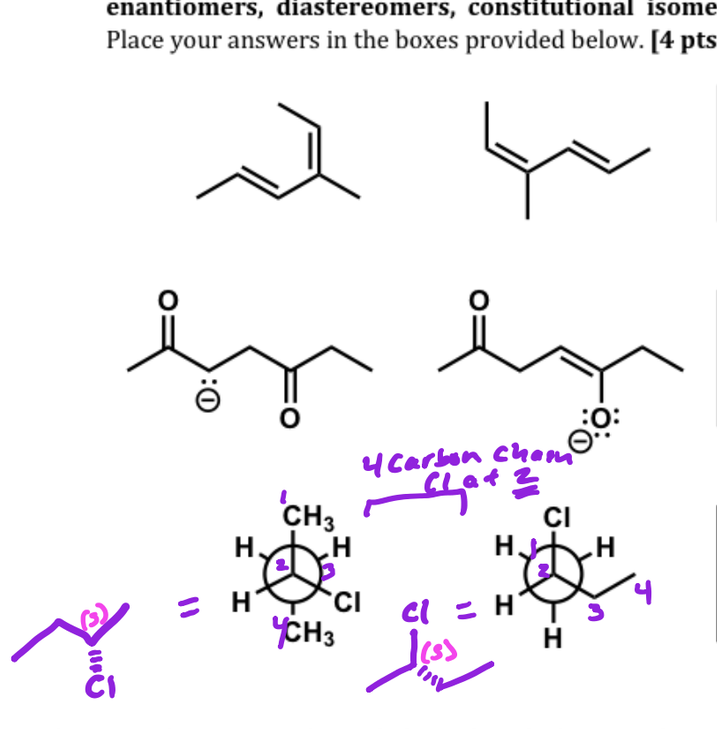
The oxygen in this position CAN'T donate directly into the N where the (+)-charge is (less stable than the one where oxygen can donate by resonance)

7) The pKa values for the conjugate acids of the amines shown below is -7, 1, and 10, respectively. Only Amine C's conjugate acid has the expected pKa value of 10. **In 10 words or less** explain why the **conjugate acid of Amine A** has such a low pKa. Do not provide an explanation for Amine B, only Amine A. **[4 pts]**



Explanation:
A → aromatic
Conj. acid A → antiaromatic
A highly favored

8) State the relationship between the following pairs of molecules selecting from the following options: **enantiomers, diastereomers, constitutional isomers, identical, resonance structures, unrelated**. Place your answers in the boxes provided below. **[4 pts each, 12 pts total]**

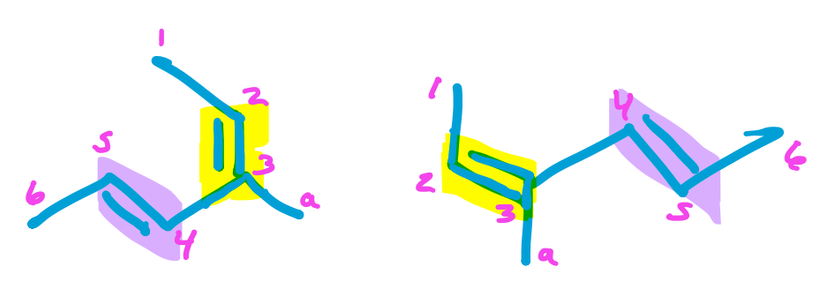


identical

Constitutional isomers

identical

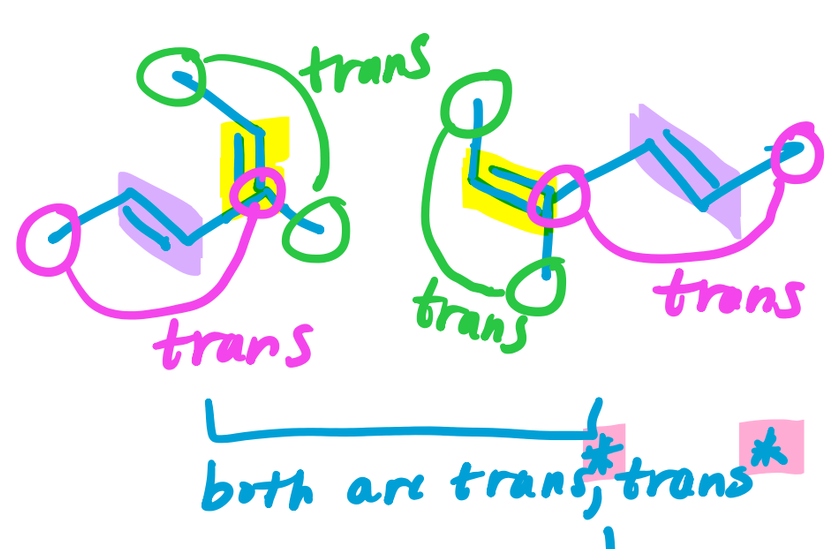
enantiomer was accepted for full credit, but is not correct. I didn't want to penalize people who recognized there was a chiral center but improperly did R/S when some people didn't recognize and got full credit



C=C both highlighted in yellow have the same substituents
C=C both highlighted in purple have the same substituents

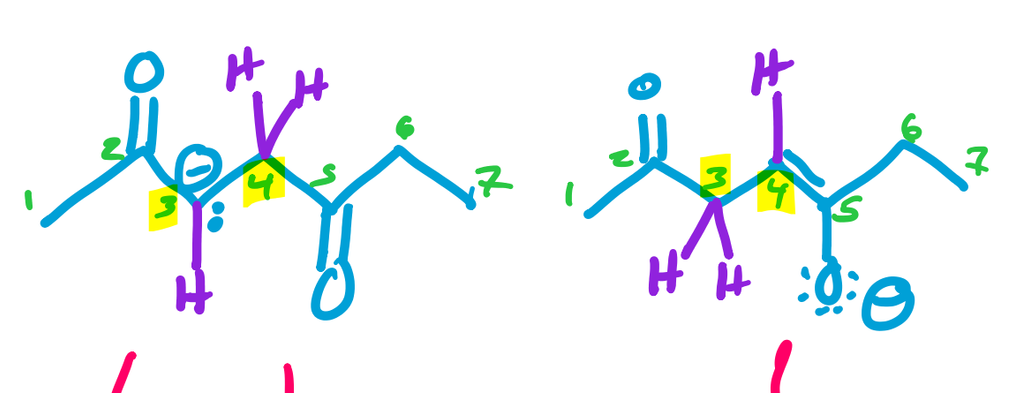
Since you have the same connectivity of atoms, they must be either:

1) Identical
or
2) Diastereomers (cis/trans, E/Z isomers)



both are trans, trans* → IDENTICAL

*The cis/trans labels here are just for the purposes of seeing if the relative configuration between groups is the same or different from one structure to the next

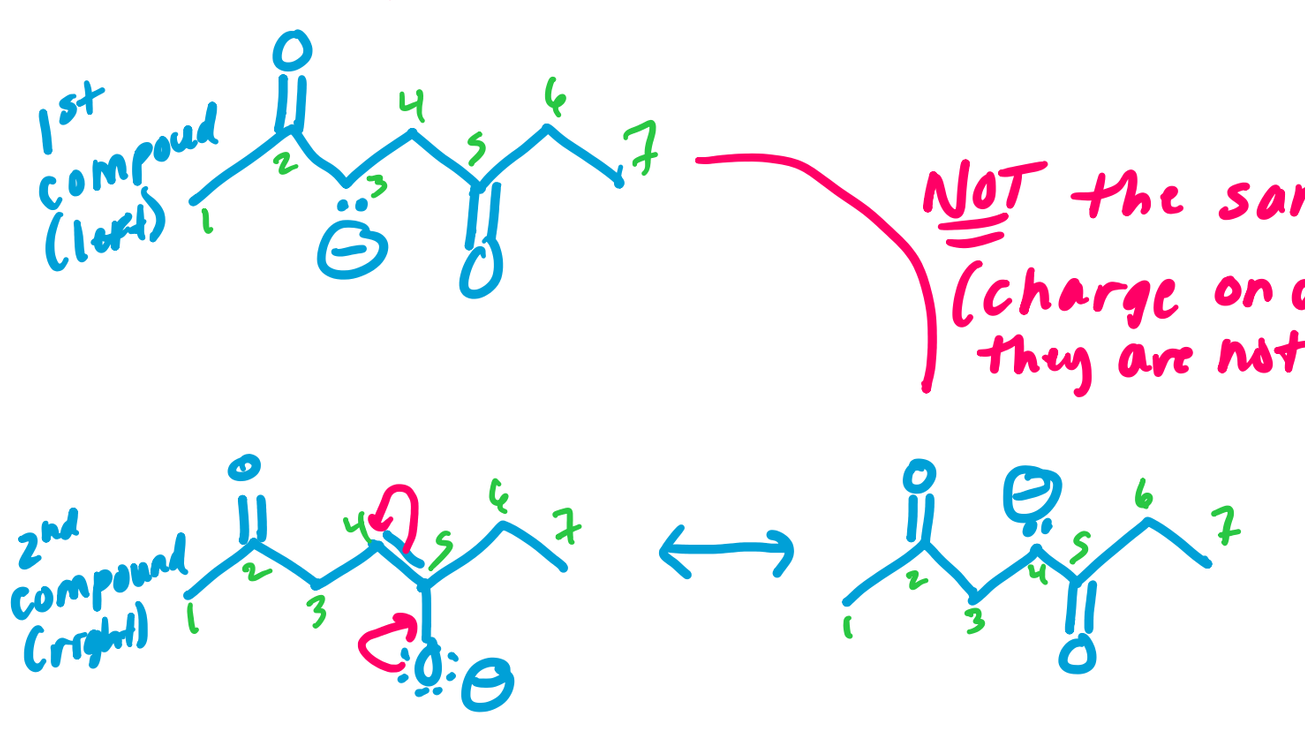


- Same molecular formula → 7C chain w/ C=O at C2 and C5 (and same net charge, −1)
- diff connectivity of atoms

1^{st} structure has 1H at C3, 2H at C4
2^{nd} structure has 2H at C3, 1H at C4

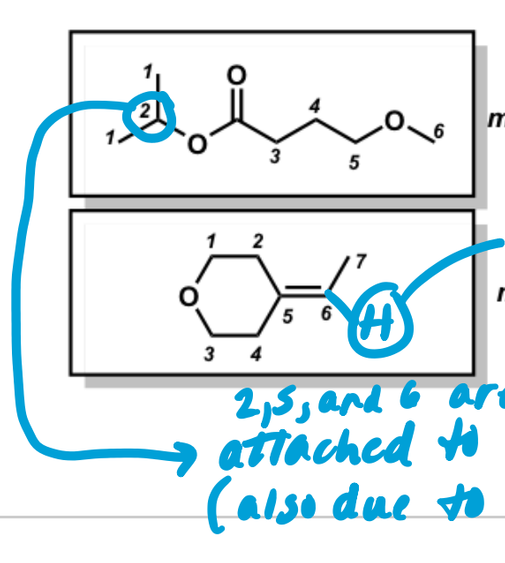
Resonance structures move only e^-, not atoms → as a result, these are not resonance structs of one another

To clarify further:



NOT the same (charge on diff atoms, they are not resonance structures of one another)

9) For each structure shown below, identify the most downfield proton(s) in ^{1}H NMR by indicating the carbon to which they are attached using the numbering shown below. **[3 pts each, 6 pts total]**

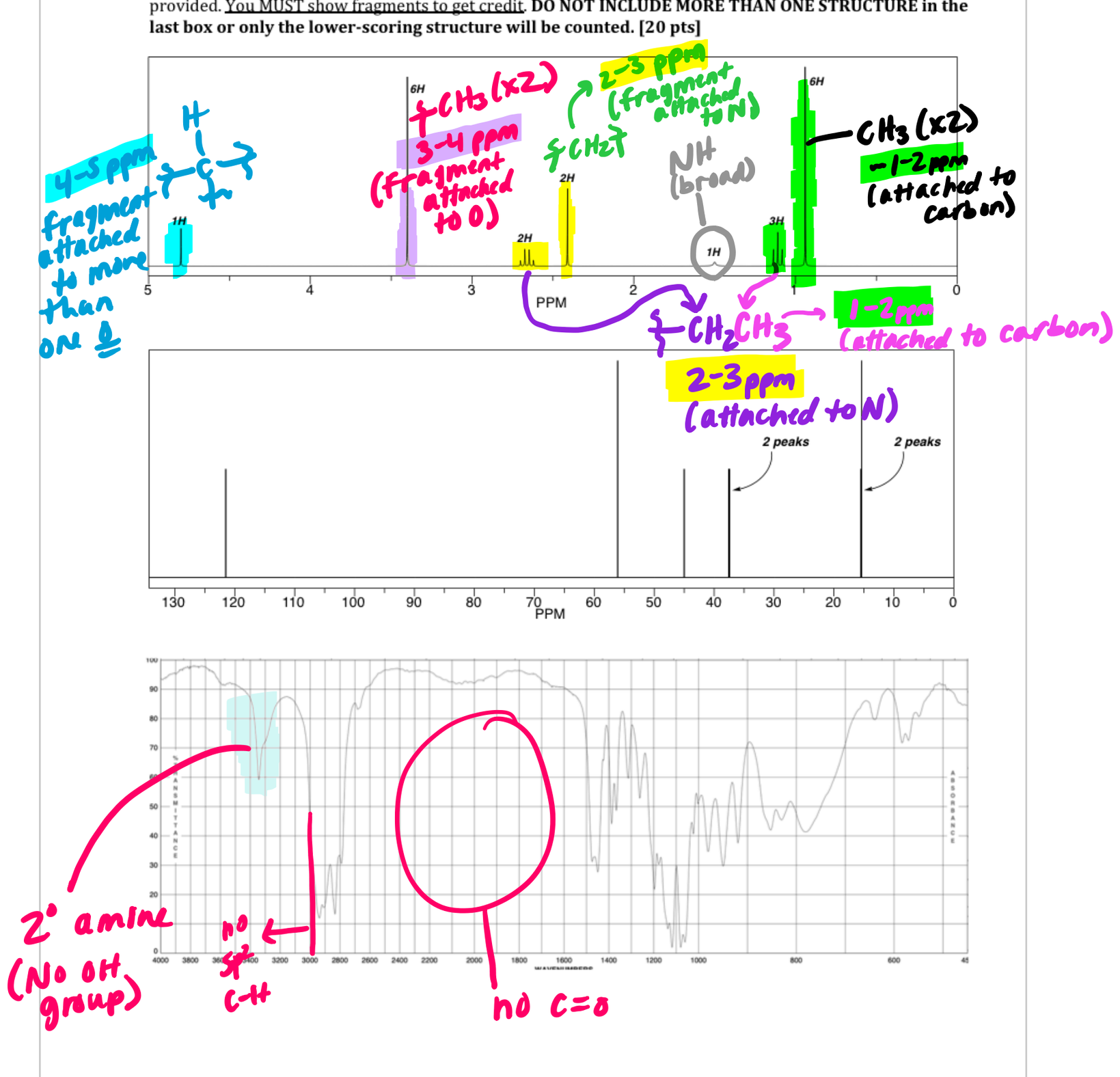


most downfield H is on carbon #: 2

most downfield H is on carbon #: 6 — alkene H (5-6 ppm)

2, 5, and 6 are all attached; attached to more carbons than 5 or 6 (methyl, methylene, methine) (also due to resonance, but the above explains it too)

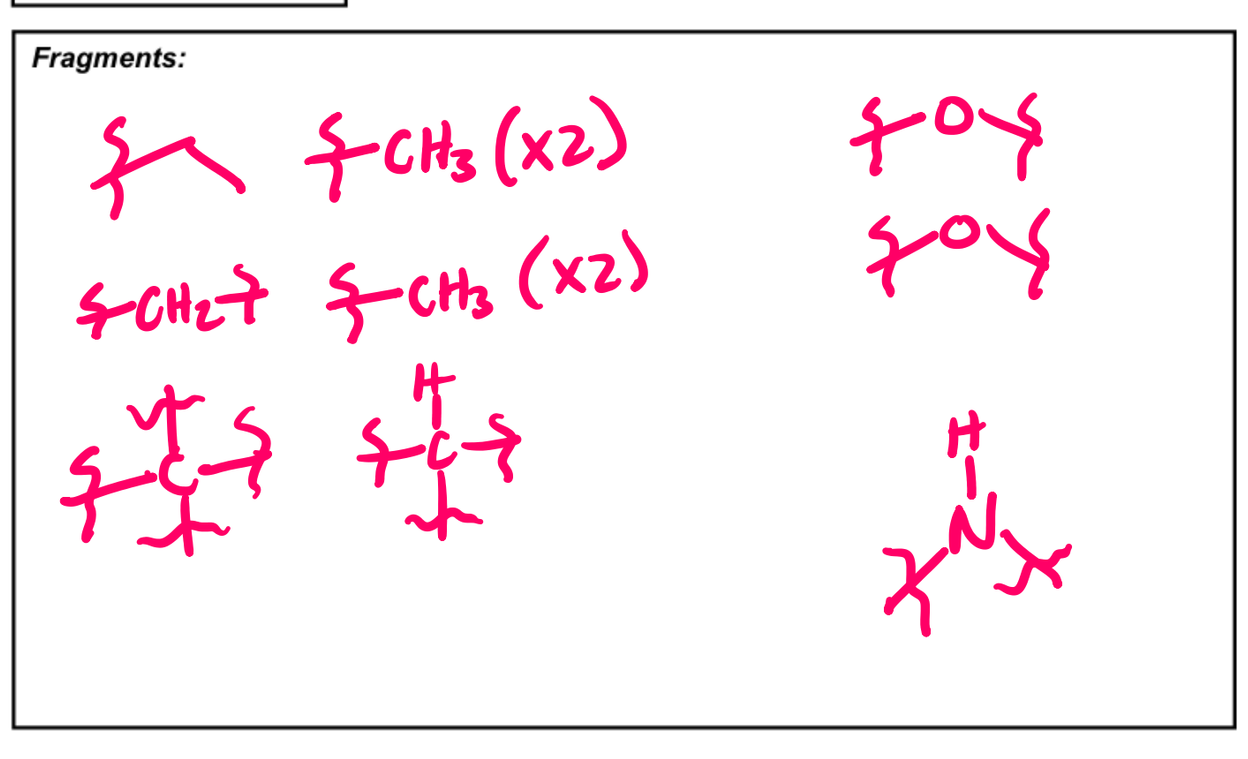
10) Determine the structure a compound having the molecular formula $C_9H_{21}NO_2$ based on its ^{1}H NMR, ^{13}C NMR, and IR spectra. On the next page, provide the IHD, structural fragments, and your final structure in the spaces provided. <u>You MUST show fragments to get credit</u>. **DO NOT INCLUDE MORE THAN ONE STRUCTURE in the last box or only the lower-scoring structure will be counted. [20 pts]**



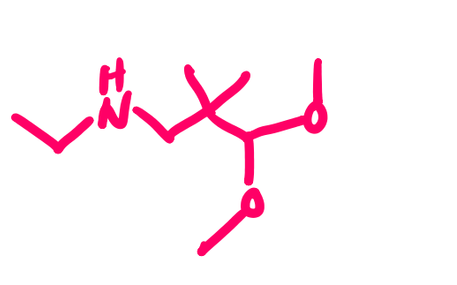
Problem 10 Answer Page

IHD = 0

Fragments:



Structure:



[20 points]

Partial Credit Structures

Any connectivity that changed the splitting got credit for fragments and IHD ONLY [max of 10/20] (same as midterm 2)

If you got > 10 pts, you got credit beyond fragments and IHD depending on how well the chemical shifts matched