

Answer
Key

CHEM 243
ORGANIC CHEMISTRY I - Fall 2024
Exam I Information and Study Guide

Answer
Key

CHEM 243 Exam I is scheduled for **Friday, September 27 in DMF 477/481**. You must take the exam in-person, and during your normal class time. I will allow 10-20 minutes of extra time, so you can start 10 minutes early and/or stay 10 minutes after class ends (70 minutes total).

If you need Accommodations for this exam you must provide me with documentation from the Academic Achievement Center no later than Monday, September 23.

Info Sheet: You may use your **Yellow Info Sheet** with written information on the front and back. You may **NOT** use:

- your class notebook
- power point slides
- worksheets, this Study Guide, or any answer keys
- a computer or other electronic devices

Preparing for the Exam. You are responsible for developing a **Study Schedule** that will give you 5-7 days to thoroughly review material for this exam. Make a list of questions that can be answered during class meetings or office hours. The following course resources are available to help you study for this exam:

- (1) Lecture videos
- (2) Your class notebook
- (3) Class worksheets
- (4) Exam Study Guide

Study Guide. These problems are to help you review for the exam and should be included in your comprehensive review of the class material. This Study Guide is designed in the same format as the exam. The number of problems and length of this Study Guide does not necessarily reflect the length of the actual exam. **I will post an answer key to this Study Guide on the course web page by Monday.**

Study Session - PALS, PROF & PIZZA! Thursday, September 26, 4-6 pm, 4th floor lounge

Miscellaneous Notes:

1. When you arrive for the exam please sign the attendance sheet and take your seat before I give you the exam.
2. You can use blue or black ink or black lead pencil.
3. Be neat! If I can't read your writing, I can't grade your answer.
4. You will be provided with scrap paper, a periodic table, and appropriate data tables. You need to bring your own pens, pencils, and calculator.
5. You will not be allowed to share any materials with another student during the exam.
6. Cell phones must be muted and put away during exams. If you need your cell phone, please let me know.
7. Academic dishonesty on exams will result in dismissal from the class and an F course grade.

PLEASE READ!!! Please contact me immediately if you can not take the exam! Students who have a documented illness (note from a physician) or personal emergency, can receive **ONE** make-up exam during the semester. All students also have the option to replace your lowest exam grade by taking the optional "Exam V" at the end of the semester.

If you arrive late and have a reasonable excuse, you can still take the exam!

KEY CONCEPTS FOR REVIEW. Exam I will cover all material on videos 1-1 to 1-3, 2-1 to 2-5, 3-1 to 3-5, plus Worksheet "Zero" to Worksheet #7.

Chapter 1: Valence electrons; Lewis structures; covalent bonds; sigma and pi bonds; single, double, triple bonds; hybridization and molecular geometry; formal charge; drawing organic structures; comparing organic structures (constitutional isomers, identical, different).

Chapter 2: Identifying functional groups; 1°, 2°, 3° designations for sp³ carbon; hydrogen deficiency; IR spectroscopy; identifying the structure of organic compounds.

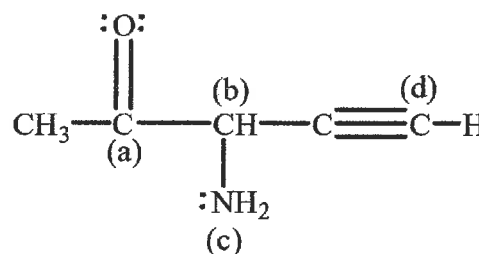
Chapter 3: Definition of Bronsted acids and bases; relationship between acid strength, pH and pK_a; predicting the mechanism and products of acid/base reactions; predicting acid/base strength based on structure (electronegativity trends, ionic size, inductive effects, resonance); drawing resonance structures and a resonance hybrid; predicting structure based on pK_a and pH.

SUPPLEMENTAL REVIEW PROBLEMS. These are additional problems to help you review for the exam; I will post an answer key by Monday. These problems should be included with your review of the lecture videos, class notes, worksheets, and the posted resources.

(1) Answer the following questions as indicated.

(a) For the structure drawn at the right, what is the Hybridization and Geometry for atoms labeled (a) – (d):

- (a) sp² and trigonal planar
 (b) sp³ and tetrahedral
 (c) sp³ and trigonal pyramidal
 (d) sp and linear

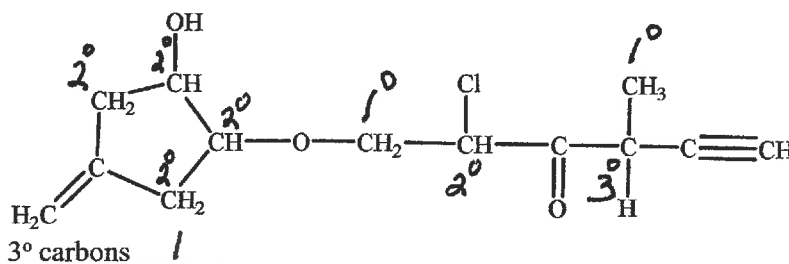


For the compound drawn above, what are the total number of sigma covalent bonds: 13

For the compound drawn above, what are the total number of pi covalent bonds: 3

(b) For the compound drawn at the right, indicate the number of:

1° carbons 2 2° carbons 5 3° carbons 1



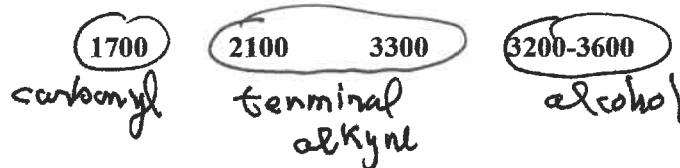
For the structure drawn above:

(i) How many pi bonds are there? 4 × H₂O₂ = 8

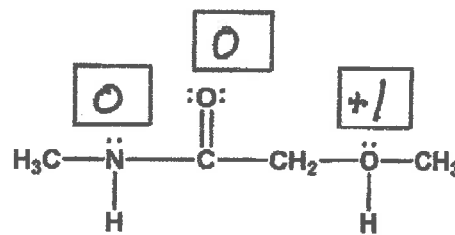
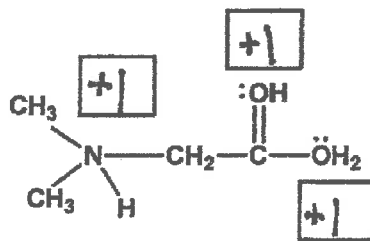
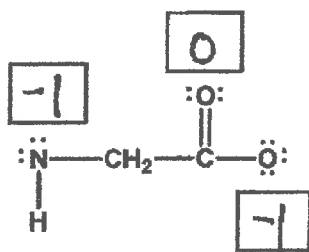
(ii) How many rings are there? 1 × H₂O₂ = 2

(iii) Based on your answers to (i) & (ii), what is the Hydrogen Deficiency? 10

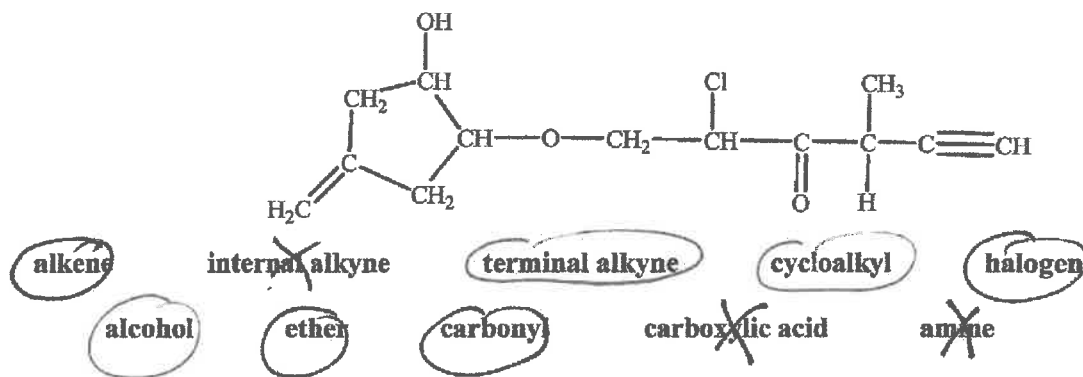
(iv) Based on the functional groups in the compound above, which of the following IR bands might be present (circle):



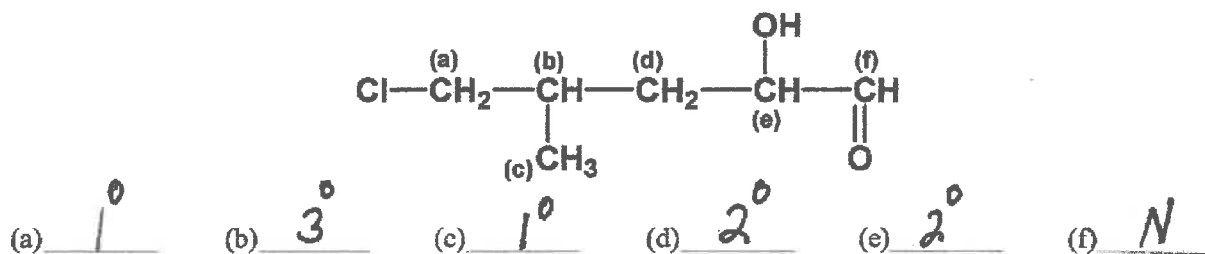
(c) In each box enter the **Formal Charge** for every N and O atom in the molecules below (0 or -1 or +1):



(d) In the molecule drawn below, which of the following functional groups are present? Circle your choice(s).



(e) Are the labeled carbon atoms in the molecule below 1°, 2°, 3° or Neither (N)?



(f) Two un-labeled vials were found in the organic chemistry stockroom. The crystalline solids in each vial were analyzed, and found to have the same molecular formula: C₇H₁₆O. Are the following statements about these compounds **TRUE** or **FALSE**:

False They are neither identical or constitutional isomers (they must be different)

False The Hydrogen Deficiency is 2 (if false, then what is the HD?) 0

False The unknowns may be an alcohol or an ether or contain a carbonyl

False Each unknown contains a double bond or a ring

True If no ring or double bond is present, then all carbon atoms must be sp³ hybridized

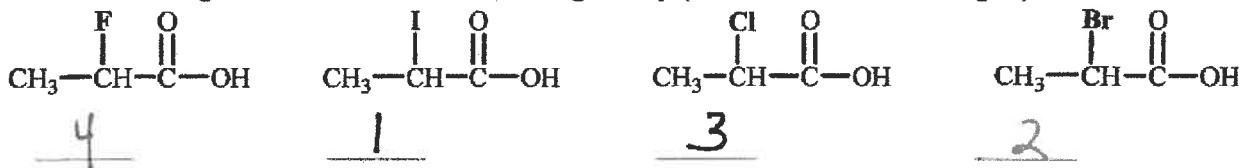
(g) Rank the following molecules in order of increasing acidity (1 = weakest.....4 = strongest).



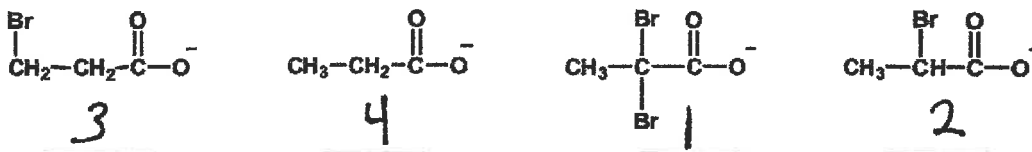
(h) Rank the following molecules in order of increasing acidity (1 = weakest.....4 = strongest).



(i) Rank the following molecules in order of increasing acidity (1 = weakest.....4 = strongest).

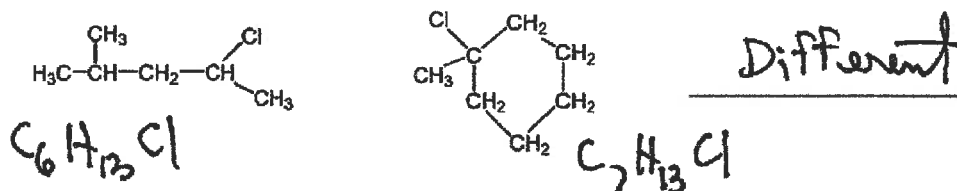
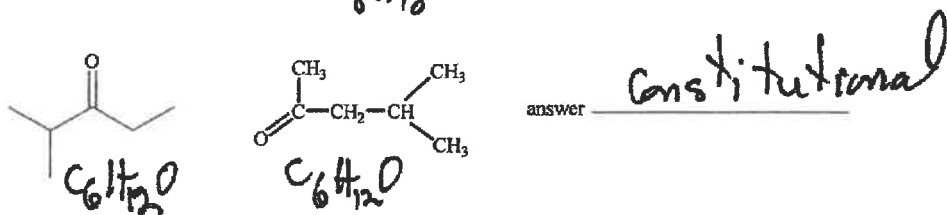
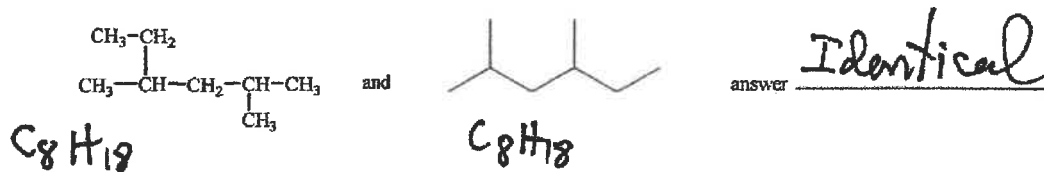
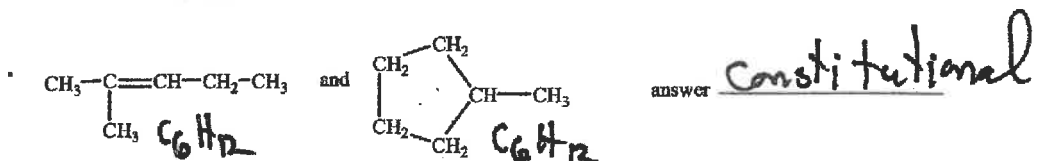


(j) Rank the following molecules in order of **base strength** (1 = weakest.....4 = strongest).

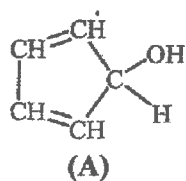


(2) Comparing Organic Structures. Are the following pairs of compounds:

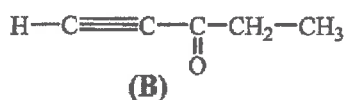
Identical or Different or Constitutional Isomers



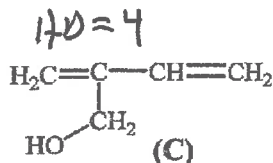
(3) **Organic Structure Identification.** An unknown organic compound with a formula of C_5H_6O is thought to be one of the molecules drawn below (A - D):



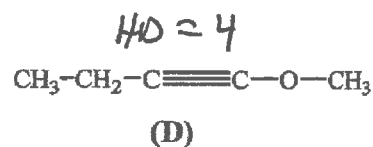
$$HD = 6$$



$$HD = 6$$



$$HD = 4$$



$$HD = 4$$

$$HD = (2n + 2) - 6$$

$$12 - 6$$

$$HD = 6$$

(a) Calculate the Hydrogen Deficiency for this unknown: 6

(b) Based on the HD and Formula, what type(s) of functional groups might be present? CIRCLE all possibilities from the list below:

alkene
(C=C double bond)

carbonyl
(C=O double bond)

alkyne
(C≡C triple bond)

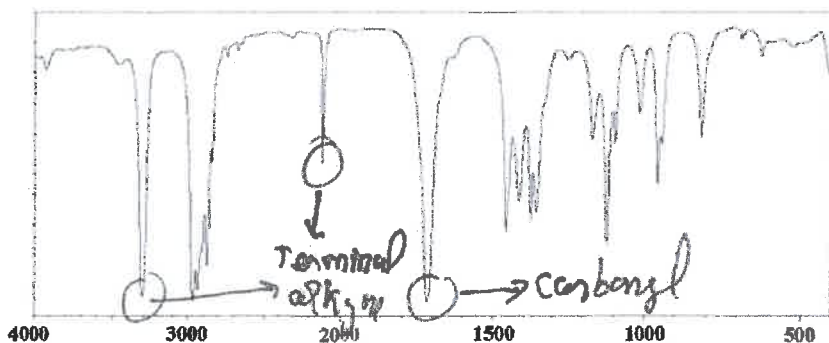
alcohol
(R-OH)

ether
(R-O-R)

cycloalkyl
(C atoms form a ring)

(c) Based on the information in (a) and (b), the unknown could be: **(A)** **(B)** (C) (D) (circle all that apply)

(d) The IR spectrum for this unknown is given below. Place an "X" for each functional group consistent with the IR data:



alcohol

terminal alkyne

internal alkyne

carbonyl

none of these

If "none of these", is there a hidden functional group? HINT: Look at your answer to (b).

(e) Based on your answer to (c), and the IR spectrum in (d), can you identify the unknown? **Explain:**

The unknown must be (B), This compound has a terminal alkyne + a carbonyl which are consistent with the IR

(4) **Organic Structure Identification.** An unknown organic compound has a molecular formula of $C_6H_{14}O$.

(a) Calculate the Hydrogen Deficiency for this unknown: 0

(b) Based on the HD and Formula, what type(s) of functional groups might be present? CIRCLE all possibilities from the list below:

alkene
(C=C double bond)

carbonyl
(C=O double bond)

alkyne
(C≡C triple bond)

alcohol
(R-OH)

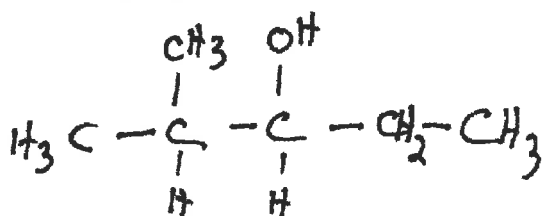
ether
(R-O-R)

cycloalkyl
(C atoms form a ring)

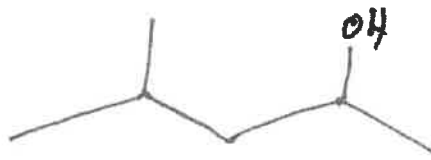
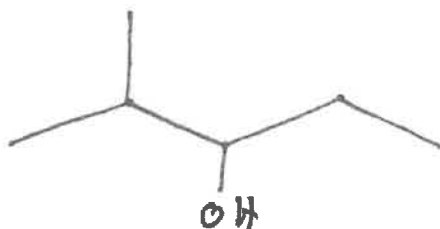
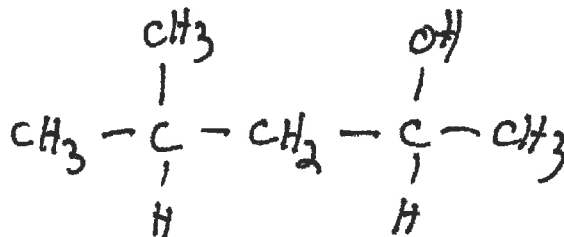
(c) The IR for the unknown has a broad band between $3200-3500\text{ cm}^{-1}$. What functional group is suggested?

This band indicates an alcohol: R-OH

(d) The unknown has three 1° carbons, two 2° carbons and one 3° carbon. The oxygen is bonded to a 2° carbon. In the space below, draw two constitutional isomers for this unknown that are consistent with all the data given to you (bond-line or zig-zag).



+



(5) **Basic Calculations (use correct significant figures and units).** For the compound in problem #4 ($C_6H_{14}O$):

(a) Determine the molecular mass of this molecule (4 significant figures): 102.2 g/mole

(b) If you had 0.1061 moles of this compound, how many grams would you have? 10.84 g

(c) You accidentally spilled this compound on the lab bench. You used a glass pipette to recover as much as possible. After re-weighing, you now have 5.771 g.

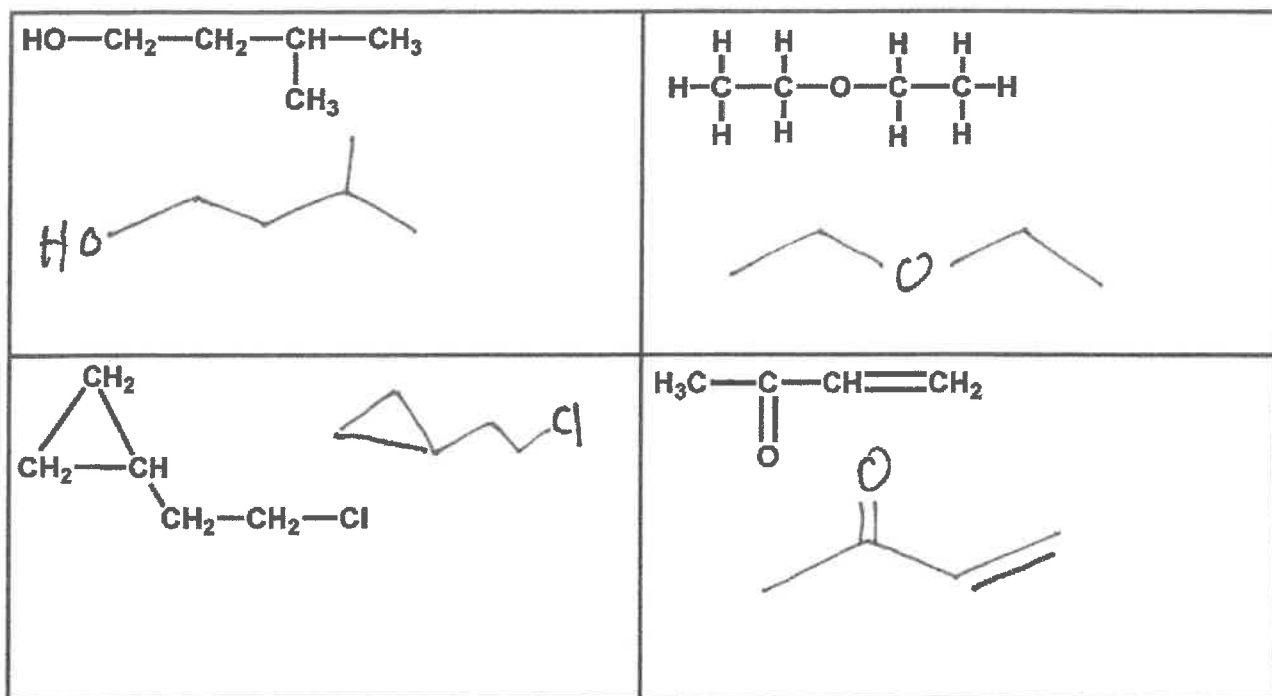
Calculate your % Recovery 53.24 %

Show your work below and use correct significant figures and units:

$$0.1061 \text{ moles} \times \frac{102.2 \text{ g}}{\text{mole}} = 10.84 \text{ g}$$

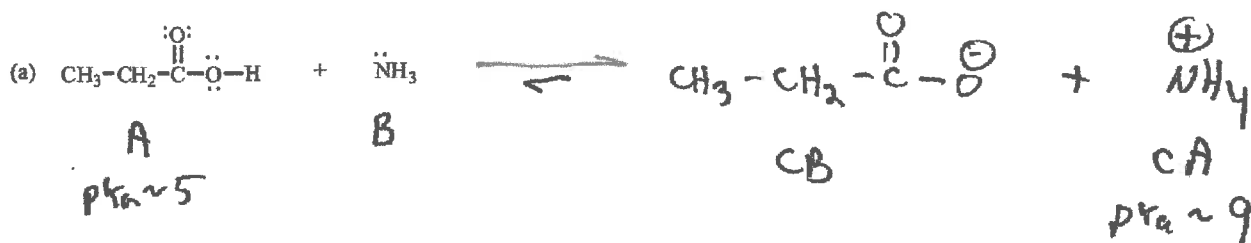
$$\frac{5.771 \text{ g}}{10.84 \text{ g}} \times 100 = 53.24 \%$$

(6) "Zig-Zag" structures. Re-draw each of the following four compounds as "zig-zag" structures.

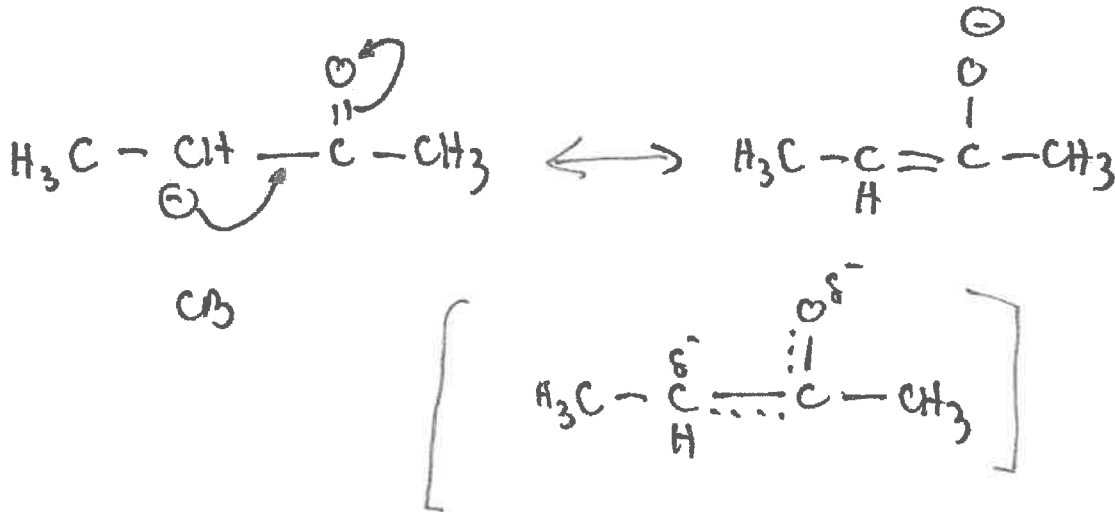
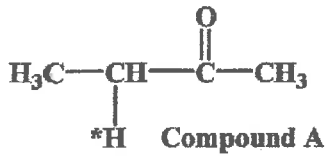


(7) Acid/Base Reactions and Mechanisms. Illustrate the complete mechanism for each of the acid-base reactions shown below. You must complete each of the following exercises:

- Label the acid and base on the reactant side of the equation;
- Use curved arrows to indicate the flow of electrons;
- Draw the products of the reaction, and make sure that the equation is balanced;
- Label the conjugate acid and base;
- Assigning approximate pKa values to the reactant acid and product conjugate acid;
- Drawing equilibrium arrows that clearly show in which direction the reaction is favored.

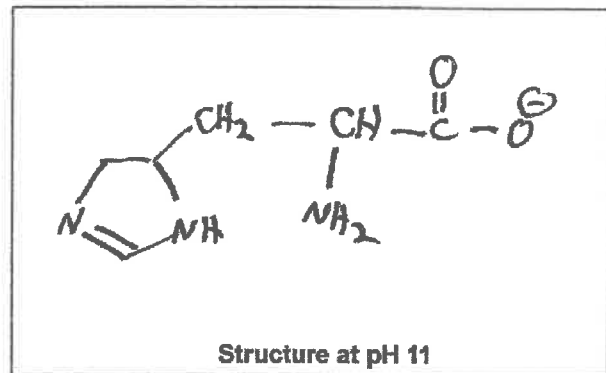
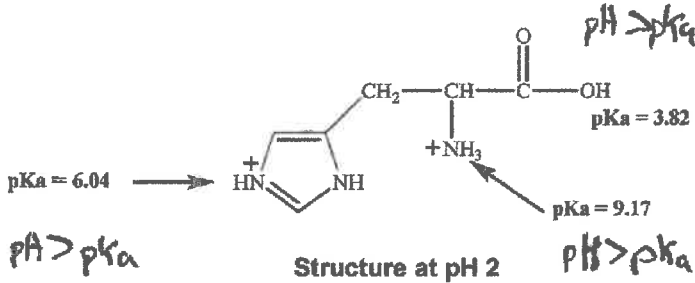


(8) **Resonance.** The H* proton indicated in the molecule below has a pKa about 20. A strong base removed the *H forming the conjugate base of Compound A. Draw the conjugate base of Compound A, all Resonance Structures, and the Resonance Hybrid.



(9) **Effect of pH on Acid/Base Structure.** The compound drawn below is shown as it would exist at pH 2.

(a) In the box, draw the structure as it would exist at pH 11.



(b) At which pH (2 or 11) would this compound be more soluble in water? BRIEFLY explain.

more soluble at pH 2 as the compound is more charged (2x \oplus) vs pH 11 with just one charge (\ominus).