

# Practice Tests, Organic Chemistry I Table of Contents

Online Organic Chemistry I, Chem 350, Dr. Craig P. Jasperse, Minnesota State University Moorhead

For full class website, see

<https://collaborate.mnstate.edu/public/blogs/jasperse/online-organic-chemistry-courses/online-organic-chemistry-i-350-fall-spring/>

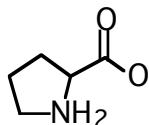
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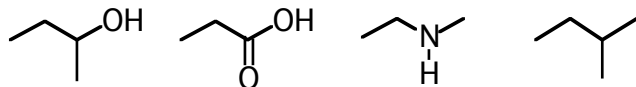
JASPERSE CHEM 350 TEST 1 VERSION 1 Organic Chemistry I - Jasperse  
Intro and Review  
Structure and Properties of Organic Molecules  
Structure, Nomenclature, and Conformation/Stereochemistry of Alkanes

1. Draw the correct Lewis structure of  $\text{CH}_3\text{CN}$ . (Needn't show 3-D geometry) (3pt)
2. Draw the correct Lewis structure for  $\text{HOCH}_2\text{CHO}$ . (Needn't show 3-D geometry). (3pt)
3. Draw a 3-dimensional picture for the atoms in  $\text{CH}_3\text{CO}_2\text{CH}_2\text{NHCH}_3$ , using the hash-wedge convention. (You needn't specify lone pairs, and orbitals need not be shown). (5pt)
4. For the structure shown, what is the hybridization, electron-pair geometry, and approximate bond angle (90, 109, 120, or 180) relative to: (6pt)
 

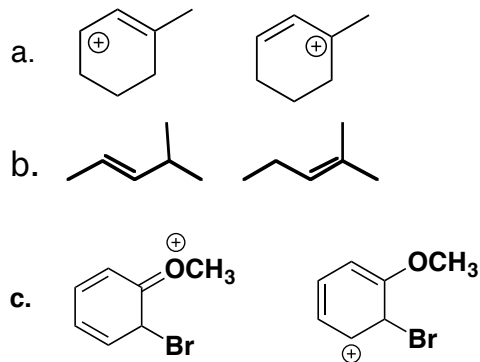
| hybridization | electron-pair<br>geometry | bond<br>angle | hybridization | electron-pair<br>geometry | bond<br>angle |
|---------------|---------------------------|---------------|---------------|---------------------------|---------------|
| O-1           |                           |               | C-5           |                           |               |
| C-2           |                           |               | N-7           |                           |               |
| C-3           |                           |               | O-9           |                           |               |
5. Assign any formal charges to any appropriate atoms for proline, given the structure shown (one of the body's 20 monomers from which protein and enzyme biopolymers are constructed). (3pt)



6. Rank the acidity of the following, from 1 (most) to 4 (least). (4pt)



7. Which of the following represent pairs of resonance structures? (4pt)

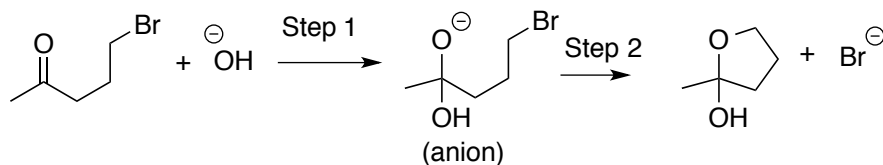


d. Both a and c

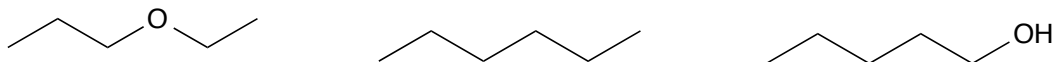
e. a, b, and c are all resonance structures.

8. Draw arrows to show electron-movement in the following two steps (draw arrows for each step).

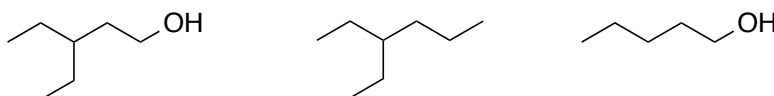
(5pt)



9. Rank the series on the basis of boiling point, 1 having highest boiling point, 3 having lowest. (3pt)



10. Rank the series on the basis of water solubility, 1 having highest solubility, 3 having lowest. (3pt)





11. For each of the following pairs of resonance structures, circle the one that would make a greater contribution to the actual resonance hybrid. (4pt)



12. Cyclopropane is much more “strained” than cyclopentane. Why? (Short!) (3pt)

13. For the following acid-base reaction,

a. put a box around the weakest base in the reaction

b. put a circle around the weakest acid

c. draw an arrow to show whether the equilibrium goes to the right or left. (4pt)



14. Classify the relationship between the pairs of molecules as either: (8pt)

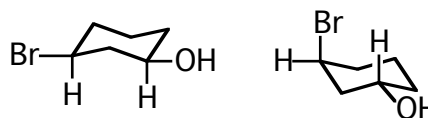
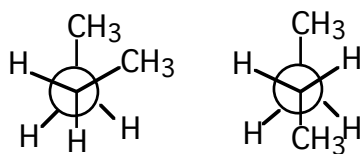
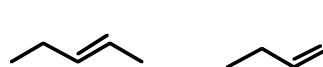
same compound

structural isomers

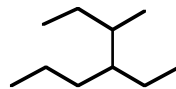
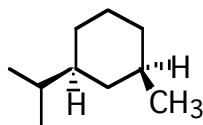
resonance structures

geometric isomers

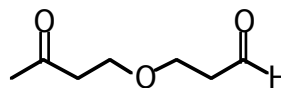
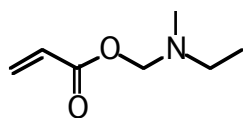
not isomers (different molecular formulas)



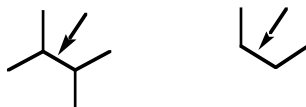
15. Give the name for the following. (7pt)



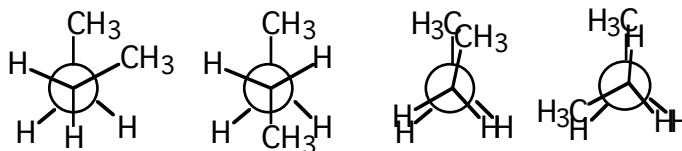
16. Identify all the functional groups in the following molecules. (Do not include “alkane”, since that isn’t “functional”.) (6pt)



17. Which of the following pair will have the larger rotation barrier, relative to the bonds indicated? (3pt)



18. For the following Newman projections, rank them in stability from 1 to 4, 1 being most stable. Identify the “anti” conformation, the “gauche” conformation, and the “totally eclipsed” conformation. (6pt)



19. Draw the Newman projection for the most stable conformation of 1,2-dichloroethane. (3pt)

20. Draw the two chair conformations of cis-1-ethyl-4-methylcyclohexane. (You don't have to draw all the hydrogens). (5pt)

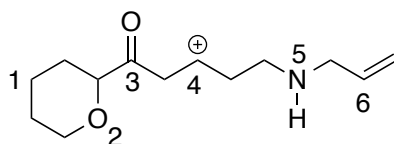
21. Which is more stable, cis- or trans-1-t-butyl-2-methylcyclohexane? Draw the best conformation of the more stable isomer. (4pt)

22. Draw as many structural isomers as you can for  $C_6H_{14}$ . Be careful not to draw the same isomer twice! I will take off points for duplicating! (6pt)



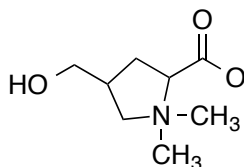
JASPERSE    CHEM 350    TEST 1    VERSION 2    Organic Chemistry I - Jasperse  
Intro and Review  
Structure and Properties of Organic Molecules  
Structure, Nomenclature, and Conformation/Stereochemistry of Alkanes

1. Draw the correct Lewis structure of  $\text{CH}_3\text{CO}_2\text{CH}_2\text{COCH}_3$ . (Needn't show 3-D geometry) (3pt)
2. Draw a 3-dimensional picture for the atoms in  $\text{CH}_3\text{CH}_2\text{CHCHCH}_2\text{NHCH}_2\text{CHO}$ , using the hash-wedge convention. (You needn't specify lone pairs, and orbitals need not be shown). (5pt)
3. For the structure shown, what is the hybridization, electron-pair geometry, and approximate bond angle (90, 109, 120, or 180) relative to: (7pt, 2 points off for each error)

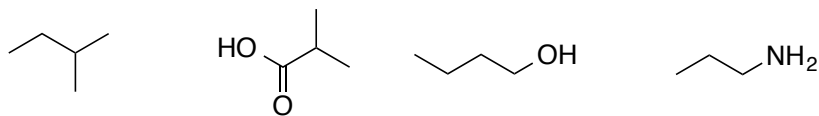


| hybridization | electron-pair geometry | bond angle | hybridization | electron-pair geometry | bond angle |
|---------------|------------------------|------------|---------------|------------------------|------------|
| C-1           |                        |            | C-4           |                        |            |
| O-2           |                        |            | N-5           |                        |            |
| C-3           |                        |            | C-6           |                        |            |

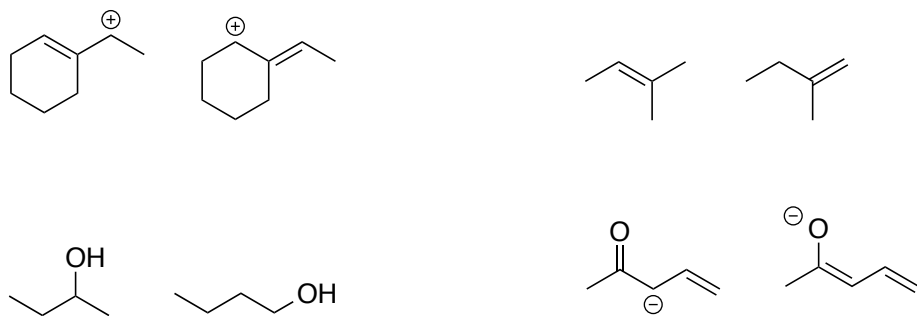
4. Assign any formal charges to any appropriate atoms for the structure shown below. (4pt)



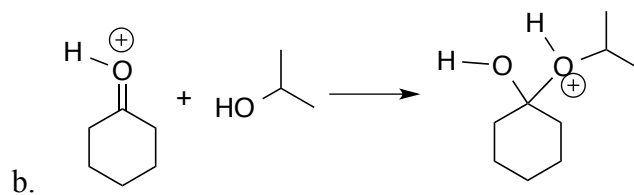
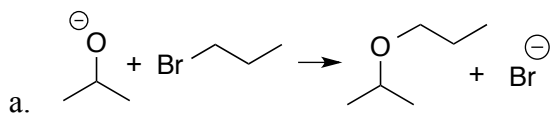
5. Rank the acidity of the following, from 1 (most) to 4 (least). (4pt)



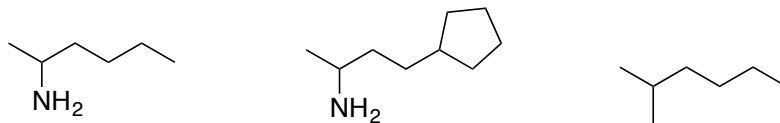
6. For the following pairs, identify as “isomers” (“I”) or “resonance structures” (“R”). (6pt)



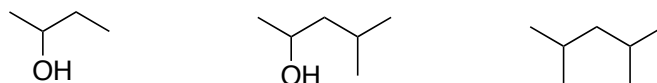
7. Draw arrows to show electron-movement in the following reactions. (These are reactions, not resonance.) (5pt)



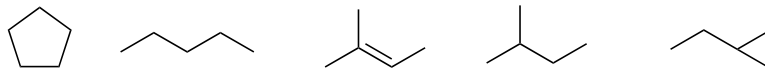
8. Rank the series on the basis of boiling point, 1 having highest boiling point, 3 having lowest. (3pt)



9. Rank the series on the basis of water solubility, 1 having highest solubility, 3 having lowest. (3pt)



10. Circle whichever of the following could fit the formula  $C_5H_{10}$ ? (3pt)



11. For the following acid-base reaction,

a. put a box around the weakest base in the reaction

b. put a circle around the weakest acid

c. draw an arrow to show whether the equilibrium goes to the right or left. (4pt)



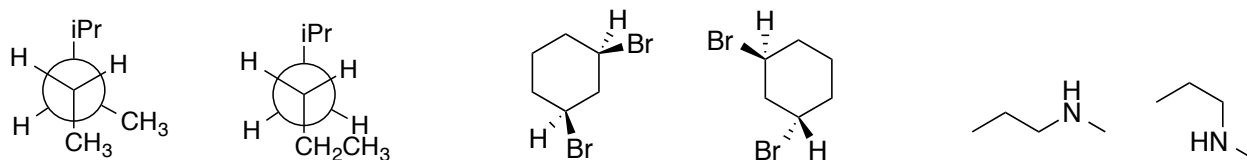
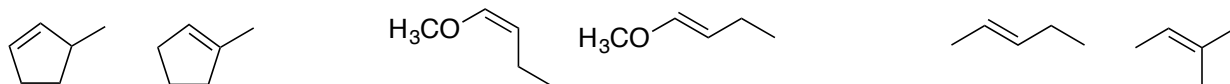
12. Classify the relationship between each pair of molecules as either: (10 pt)

same compound

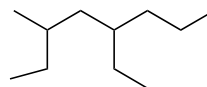
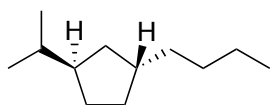
structural isomers

resonance structures

stereoisomers

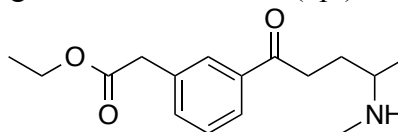
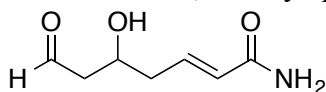


14. Give the name for the following. (7pt)

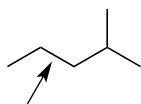


15.

16. Identify and write down the names for each of the functional groups in each of the following molecules. (Do not include “alkane”, since that isn’t “functional”.) For each molecule, try to write the names in order, as they appear from left-to-right in the molecules. (8pt)

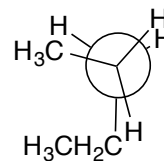
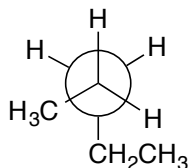
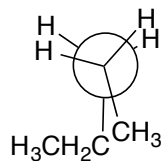
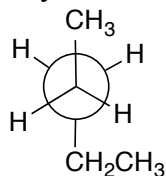


17. Circle which of the following pair will have the larger rotation barrier, relative to the bonds indicated? (2pt) Identify which reason explains why: steric strain, torsional strain, or angle strain?



18. For the following Newman projections: (6pt total)

- rank them in stability from 1 to 4, 1 being most stable
- identify the “anti”, “gauche”, and the “totally eclipsed” conformations.

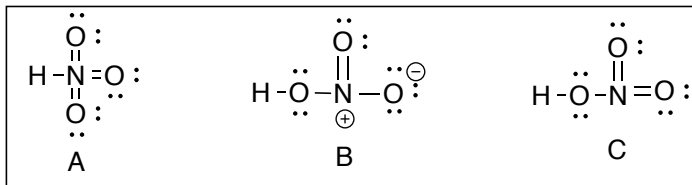


- Is the energy difference between the gauche and the anti conformation based on steric strain, torsional strain, or angle strain?
- In the case of ethane (not shown), staggered conformations are better than eclipsed conformations. Is the difference based on steric strain, torsional strain, or angle strain?

19. Draw both the most stable and the least stable Newman projections for 1-bromopropane,  $\text{BrCH}_2\text{CH}_2\text{CH}_3$ , relative to C1-C2 bond. - (3pt)



20. Which of the following are correct Lewis structures, including formal charges, for nitric acid,  $\text{HNO}_3$ . (3 pts)



21.

- a. A only
- b. B only
- c. C only
- d. Both A and C
- e. All of the above

22. Draw the **two chair conformations** of cis-1-isopropyl-4-methylcyclohexane. (You don't have to draw all the hydrogens). (5pt) (Use "iPr" as abbreviation).

23. Draw the best chair conformation of the more stable isomer. Which is more stable, cis- or trans-1-butyl-2-methylcyclohexane? (4pt)

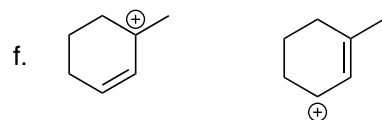
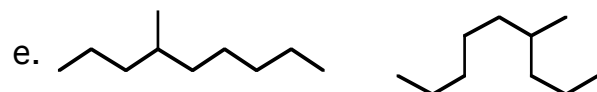
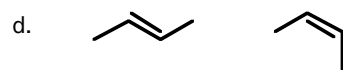
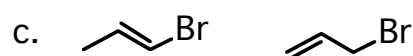
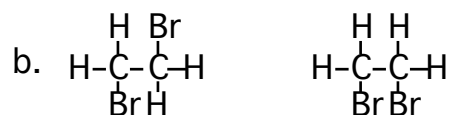
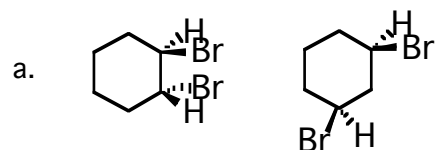
24. Draw any 6 of the 9 possible structural isomers for **alkanes** with formula  $\text{C}_7\text{H}_{16}$ . When deciding whether to draw cyclic or acyclic alkanes, make sure that you fit the formula! Be careful not to draw the same isomer twice! I will take off points for duplicating! (You can try to show off by getting more than 6, but if you do still be sure you don't duplicate!) (6pt)



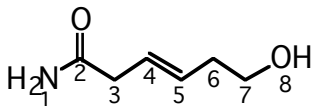
JASPERSE CHEM 350 TEST 1 VERSION 3 Organic Chemistry I - Jasperse  
 Intro and Review  
 Structure and Properties of Organic Molecules  
 Structure, Nomenclature, and Conformation/Stereochemistry of Alkanes

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)



2. (8 points) Draw line-angle structures and names for 4 of the 5 structural isomers of  $C_6H_{14}$ .



3. (10 Points)

a. For the above structure, what is the hybridization and approximate bond angles (109, 120, or 180) about:

C-2

C-4

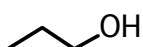
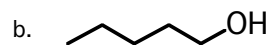
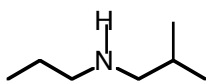
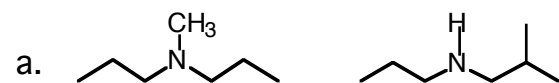
C-6

O-8

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?

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?

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



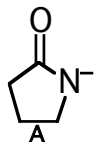
6. (6 points) Write a Lewis structure and assign any non-zero formal charges.

a.  $[\text{CH}_3\text{NH}_3]^+$

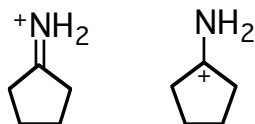
b.  $\text{CH}_3\text{CO}_2\text{Na}$

c.  $\text{CH}_3\text{CHO}$

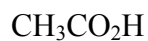
7. (5 points) a) Draw the best resonance structure for anion A, and circle the resonance structure that would make the greater contribution to the resonance hybrid.



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

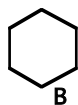


8. (6 points) Rank the acidity of the following molecules, 1 being most acidic, 4 being least acidic. Hint: draw the anions!



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.



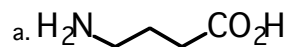
11. (6 points) Which of the following are capable of cis-trans stereoisomerism? (Yes/No).

a. 3-ethyl-1,1-dimethylcyclopentane

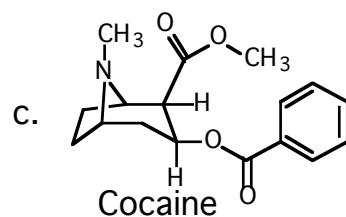
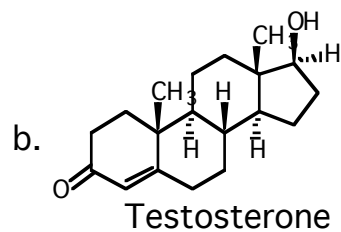
b. 3-pentene (name means a double bond is between carbons 3 and 4)

c. 1,3-dimethylcyclohexane

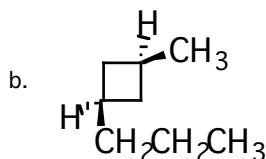
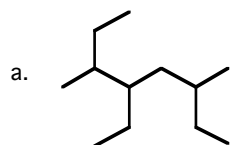
12. (9 points) Identify the functional groups in the following molecules. (Do not include "alkane", since that is not "functional". And do not specify "cyclic".)



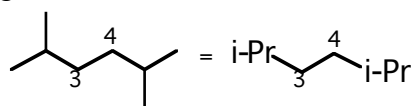
("GABA: brain neurotransmit



13. (5 points) Give the IUPAC name for the following compounds.



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.  
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-1-isopropyl-3-methylcyclohexane. (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"  
b.) Circle the more stable conformation.  
c) Would trans-1-isopropyl-3-methylcyclohexane be more stable or less stable than the cis isomer?



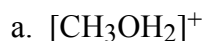


JASPERSE CHEM 350 TEST 1 VERSION 4 Organic Chemistry I - Jasperse  
Intro and Review  
Structure and Properties of Organic Molecules  
Structure, Nomenclature, and Conformation/Stereochemistry of Alkanes

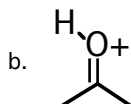
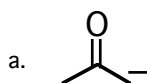
1. Order the following according to increasing electronegativity, 1 being highest, 4 lowest. (2pts)

N \_\_\_\_\_ F \_\_\_\_\_ O \_\_\_\_\_ C \_\_\_\_\_

2. Write Lewis structures and assign any non-zero formal charges. (3pts each)

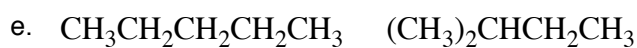
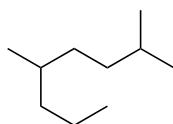
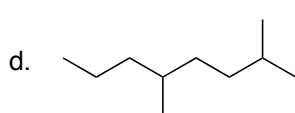
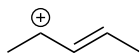
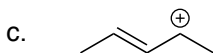
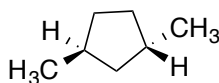
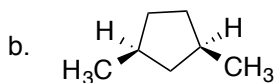
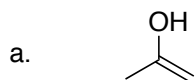


3. For each of the following, a) draw its resonance structure, and for each pair b) circle the structure that would make the greater contribution to the resonance hybrid. (2 pts each)

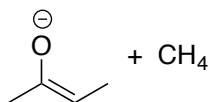
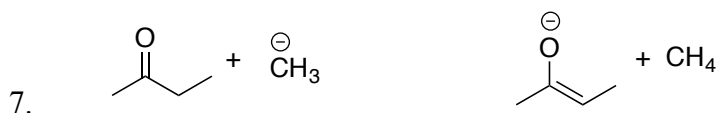
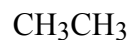
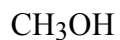


4. Draw line-angle structures for 7 of the 9 structural isomers of  $\text{C}_7\text{H}_{16}$ . (5 pts)

5. For the following pairs of structures, identify them as either: Resonance Structures, Structural Isomers, Stereoisomers, or Same. (2 pts each)

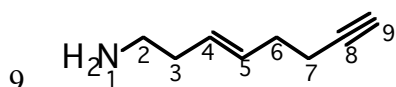


6. Rank the acidity of the following molecules, 1 being most acidic, 4 being least acidic. (3 pts)



- Put a box around the weakest base in the above reaction. (1pt)
- Put a circle around the weakest acid in the above reaction. (1pt)
- Draw an arrow to show whether at equilibrium the reaction will go left-to-right or right-to-left. (2pt)

8. Draw the line-angle structure for the following condensed structural formula:  $(\text{CH}_3\text{CH}_2)_2\text{CO}$  (3pt)



- a. For the above structure, what is the hybridization, electron-pair geometry, and approximate bond angles (109, 120, or 180) about: (6pt)

N-1

C-3

C-5

C-8

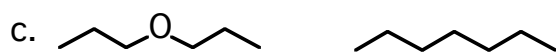
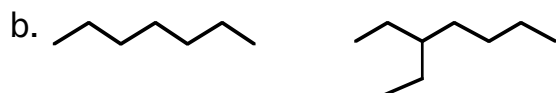
- b. Rank the length of the following bonds, 1 being shortest, 3 being longest. (2pt)

C2-C3

C4-C5

C8-C9

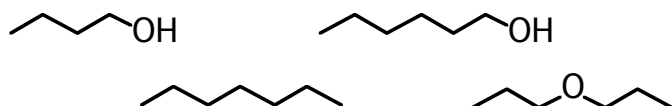
10. For each of the pairs listed, circle the one with the higher boiling point. (4pt)



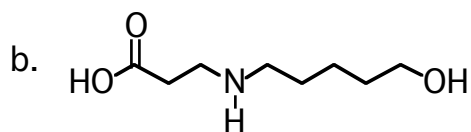
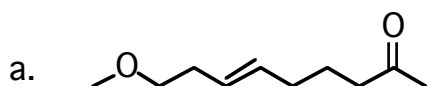
11. Draw a 3-dimensional picture for all of the atoms (hydrogens included) in the molecule  $\text{CH}_3\text{CHCHCOCH}_2\text{CH}_2\text{NHCH}_3$ . Your picture should use the hash-wedge convention to illustrate atoms that are not in the plane of the paper, and should reflect approximate bond angles. (5pt)

12. Draw a 3-D picture of  $\text{CH}_2\text{O}$  showing the  $\pi$  bond as well as the four atoms. (3pt)

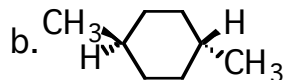
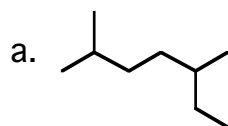
13. For the following set, rank the solubility in water, from 1 (most soluble) to 4 (least soluble). (3pt)



14. Identify the functional groups in the following molecules. (8pt)



15. Give the IUPAC name for the following compounds. (6pt)



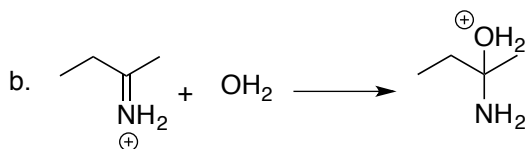
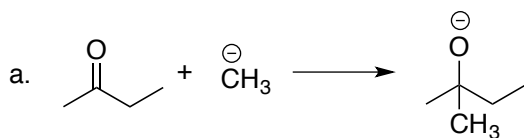
16. Draw the Newman projections for the best and worst conformations of butane, and give the names for these conformations. Briefly explain what “strain factors” make the worst conformation worse than the best conformation. (6pt)

17. a.) Draw both chair conformations of cis-1-methyl-2-isopropylcyclohexane. Draw the substituents and H-atoms attached to carbons 1 and 2. (You don't need to show the H's on the other carbons). (4pt)

b.) **Circle the more stable conformation.** (1pt)

18. Draw the best chair conformation for 1,3-diethylcyclohexane, and identify whether it is “cis” or “trans”. (3pt)

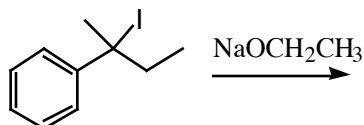
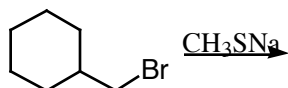
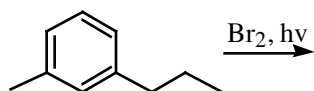
19. Use the arrow-pushing convention to show the electron-movement mechanisms for the following two reactions. (5pt)



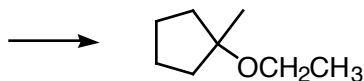


JASPERSE CHEM 350 TEST 2 VERSION 1  
 Ch. 4 The Study of Chemical Reactions; Ch. 5 Stereochemistry  
 Ch. 6 Alkyl Halides: Nucleophilic Substitution and Elimination

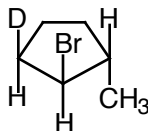
1. Predict the major organic product for each of the following. (3 points each)



2. Show an alkyl bromide and some nucleophile that you could use to make the following by  $\text{S}_{\text{N}}2$ . (3 points)



3. For the structure shown, (3 points each)  
 a. Draw the major elimination product formed upon treatment with  $\text{H}_2\text{O}/\text{heat}$ .



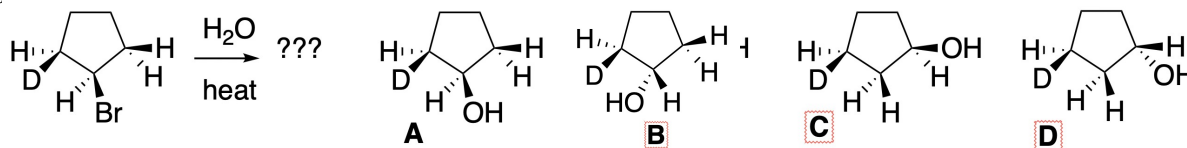
b. Draw the major elimination product formed upon treatment with  $\text{CH}_3\text{CH}_2\text{ONa}$ .

c. Draw the major substitution product formed upon treatment with  $\text{CH}_3\text{CH}_2\text{ONa}$ .

(3 points for each multiple choice question)

4. Which of the following is true regarding an  $S_N1$  reaction?
- It would be faster at  $25^\circ$  than  $50^\circ$
  - It would be faster in ethanol than in pentane
  - Keeping the moles of reactants constant but doubling the quantity of solvent would decrease the rate by a factor of 4.
  - Stereochemical inversion occurs exclusively
6. Which of the following statements is true?
- The rate determining step is always the last step in a reaction mechanism.
  - The stability/reactivity principle says that the more stable of two chemicals will be more reactive
  - The reactivity/selectivity principle says that the more reactive of two chemicals will be less selective.
  - The activation barrier for a reaction is the difference in energy between reactants and final products.
7. Which of the following statements is true about the chlorination of methane?
- In each propagation step a radical is produced
  - $6.02 \times 10^{23}$  initiation events are needed to make one mole of chloromethane
  - Most chloromethane is made by combination of a methyl radical with a chlorine radical
  - The overall chlorination of methane is strongly endothermic.
8. Which of the following statements is FALSE?
- Optically active solutions always contain chiral molecules.
  - Two diastereomers always have identical melting points
  - Optically inactive solutions are either racemic or else contain no chiral chemicals at all
  - A solution with 60% optical purity would have an 80/20 mix of enantiomers

9. When the reactants shown undergo substitution, which of the products A-D will form? (3 points)

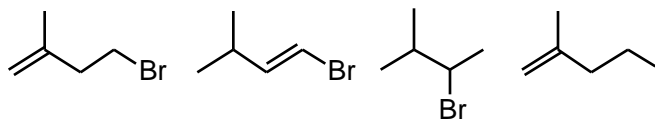


- A only
- B only
- A and B
- A, B, and C
- A, B, C, and D

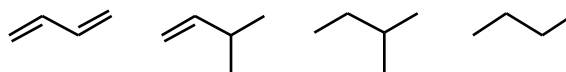


10. Rank the reactivity of the structures shown toward the reactant(s) indicated on the left (1 being most, etc.) (3 points each)

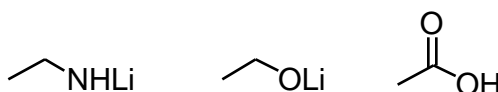
$\text{NaOCH}_2\text{CH}_3$



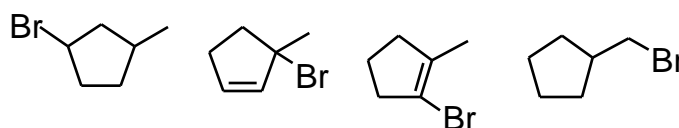
$\text{Br}_2/h\nu$



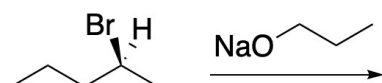
$\text{CH}_3\text{Br}$



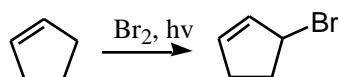
$\text{H}_2\text{O}$ , heat,  
catalytic  $\text{H}^+$



11. Draw the product(s) of the following reaction. Show substitution product(s) only. (There might be some some alkene products formed as well, but don't bother drawing those.). If two enantiomers form, draw them both. (3 points)

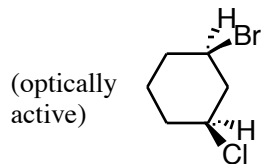


12. Draw the mechanism for the following reaction, propagation steps only. (4 points)

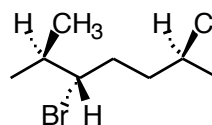
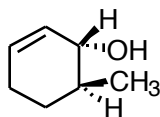


13. Draw (3R,6R)-6-bromo-3-chloro-2-methyloctane (3 points)

14. Name the following: (3 points)



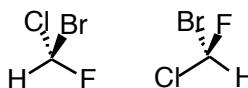
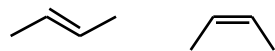
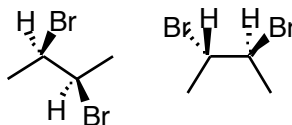
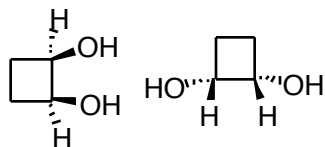
15. Classify each of the chiral carbons in the following structures as R or S (there may be more than one in a molecule). (10 points)



16. a. Classify each pair as diastereomers, enantiomers, or same. (12 points)

b. For the first structure of each pair, circle it if it is not chiral

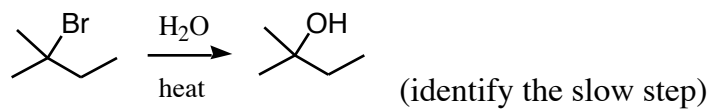
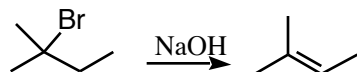
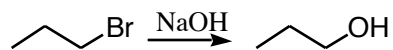
c. For the first structure of each pair, write “meso” by it if it is meso



17a. a) Draw all the unique stereoisomers of 2,3-dichlorobutane. Cross out any duplicates.

b) Identify which is meso. c) Identify a pair that are related as diastereomers. (5 points)

18. Draw the mechanisms for the following reactions, using formal arrow pushing. Note: in some case hydrogens that are not illustrated will be involved in bond changes. You would do well to write them in at the beginning. (12 points total, 3/3/6 distribution)

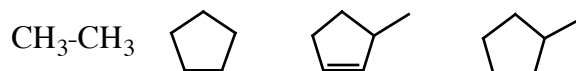




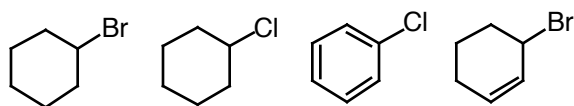
JASPERSE CHEM 350 TEST 2  
 Ch. 4 The Study of Chemical Reactions  
 Ch. 5 Stereochemistry  
 Ch. 6 Alkyl Halides: Nucleophilic Substitution and Elimination

VERSION 2

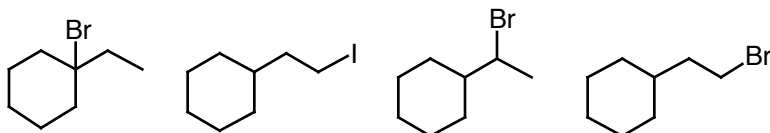
1. Rank the reactivity of the following molecules toward  $\text{Br}_2/\text{h}\nu$ . (1 most, 4 least) (3 points)



2. Rank the reactivity of the following molecules toward ethanol and  $\text{AgNO}_3$ . (1 most, 4 least) (3 points)



3. Rank the reactivity of the following molecules toward  $\text{NaOCH}_3$ . (1 most, 4 least) (3 points)

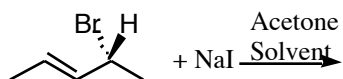
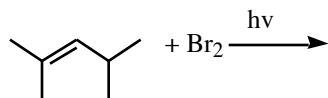
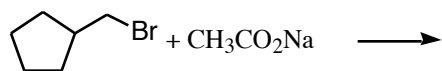


4. Rank the reactivity of the following toward 1-iodopropane. (1 most, 4 least) (3 points)

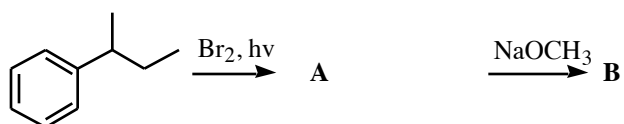


5. What is the hybridization of a carbocation? (2 points)

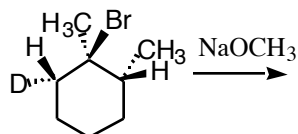
6. Predict the major organic product (1 major structure is all that is needed in each case) for each of the following reactions. (Minor products or inorganic side products need not be drawn.) (3 points each)



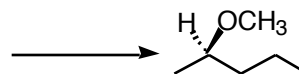
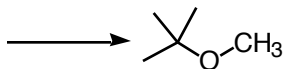
7. Draw the structures for intermediate **A** and final product **B**. (4 points)



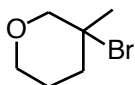
8. Draw the product when the following substance undergoes E2 elimination. ("D" is deuterium, basically just a labelled hydrogen). If the starting material is optically active, will the product be optically active? (4 points)



9. Show an alkyl bromide and some nucleophile that you could use to make the following by  $S_N2$ . (3 points each)

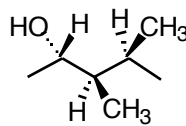
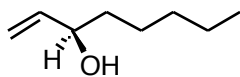
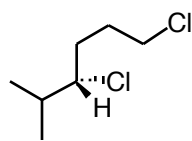


10. Draw all possible elimination products that could form from the following reactant. (5 points)



11. Which of the following would not increase the rate of an  $E1$  reaction? (3 points)
- an increase in temperature
  - an increase in the "activation energy"
  - an increase in the concentration of the alkyl halide
  - an increase in the stability of the carbocation intermediate
12. When comparing the reaction of 2-methylpropane with either  $Cl_2/h\nu$  or  $Br_2/h\nu$ , which of the following statements is true? (3 points)
- bromine is less reactive and more selective
  - chlorine is less reactive and more selective
  - bromine is more reactive and more selective
  - chlorine is more reactive and more selective
13. Which of the following statements is true relative to reactions I-III: (3 points)
- $CH_4 + Br\cdot \rightarrow CH_3\cdot + HBr$
  - $CH_3CH_3 + Br\cdot \rightarrow CH_3CH_2\cdot + HBr$
  - $CH_3CH_2CH_3 + Br\cdot \rightarrow (CH_3)_2CH\cdot + HBr$
- I has the smallest energy of activation and the highest energy transition state
  - II has the smallest energy of activation and I has the lowest energy transition state
  - III has the largest energy of activation and the highest energy transition state
  - III has the smallest energy of activation and the lowest energy transition state

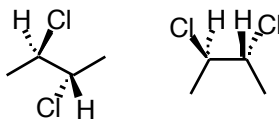
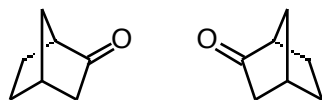
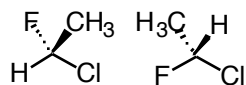
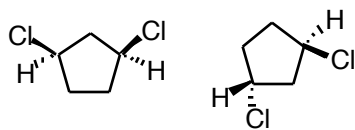
14. Classify each of the chiral carbons in the following structures as (R) or (S). (10 points)



15. a. Classify each pair of molecules as diastereomers, enantiomers, or same. (12 points)

b. Circle any molecules that are chiral

c. Write "meso" by any structures that are meso

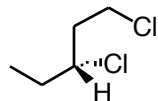


16. Which of the following statements is true? (3 points)

- All solutions with chiral molecules are optically active
- All molecules with chiral carbons are chiral
- A solution that has 50% optical purity has a 50/50 mixture of enantiomers
- Two enantiomers always have identical boiling points

17. Draw (2R,3S)-2-bromo-3-chlorohexane (3 points)

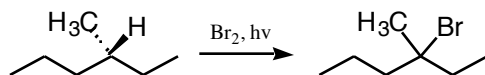
18. Name the following: (3 points)



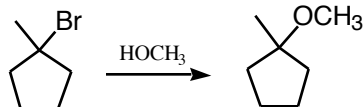


19. a) Draw all unique stereoisomers of 2,4-dibromopentane. Label each with a letter, A, B, etc.. Cross out any duplicates. (8 points)  
 b) Identify any that are chiral  
 c) Identify any that are meso

20. a) Draw the mechanism for the following reaction. (Draw the propagation steps only.) (4 points)  
 b) Is your product chiral, and if so is it optically active? (1 points)



21. a) Draw the mechanism for the following reaction. (4 points)  
 b) Identify the slow step. (1 point)

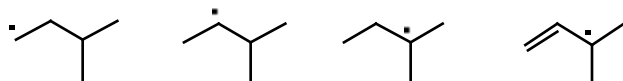




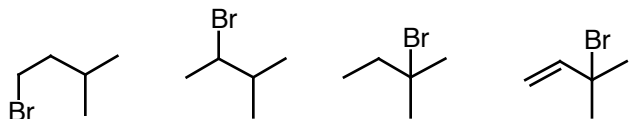
JASPERSE CHEM 350 TEST 2 VERSION 3  
 Ch. 4 The Study of Chemical Reactions  
 Ch. 5 Stereochemistry  
 Ch. 6 Alkyl Halides: Nucleophilic Substitution and Elimination

|             |              |              |                  |
|-------------|--------------|--------------|------------------|
| 1. _____ /4 | 6. _____ /9  | 11. _____ /6 | 16. _____ /4     |
| 2. _____ /4 | 7. _____ /4  | 12. Removed  | 17. _____ /6     |
| 3. _____ /4 | 8. _____ /6  | 13. _____ /6 | 18. _____ /16    |
| 4. _____ /4 | 9. _____ /10 | 14. _____ /6 | Total _____ /100 |
| 5. _____ /3 | 10. _____ /6 | 15. _____ /2 |                  |

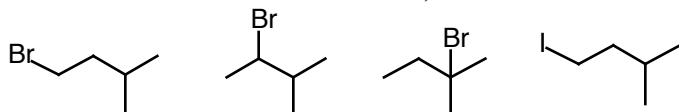
1. List the following radicals in order of increasing stability (from most stable **1** to least stable **4**)



2. List the following alkyl halides in order of decreasing reactivity toward  $S_N1/E1$  reactions (from most reactive **1** to least reactive **4**).



3. List the following alkyl halides in order of decreasing reactivity toward  $S_N2$  reactions (from most reactive **1** to least reactive **4**).



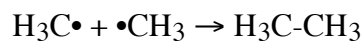
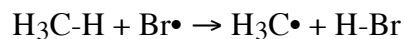
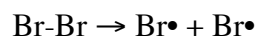
4. Rank the bond strength of the following (from strongest **1** to weakest **4**).



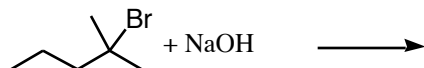
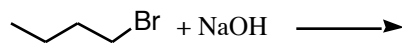
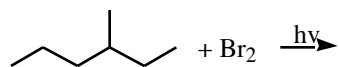
5a. Put a **1** by the reaction for which  $\Delta H^\circ = E_{\text{act}}$ . ( $E_{\text{act}}$  = activation energy)

b. Put a **2** by the reaction for which  $E_{\text{act}} = 0$ .

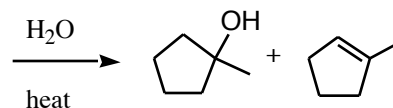
c. Put a **3** by the reaction for which  $E_{\text{act}} > \Delta H^\circ$ .



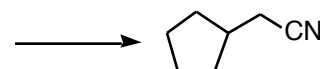
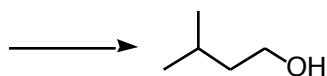
6. Predict the major organic product for each of the following reactions. (Minor products or inorganic side products need not be drawn.)



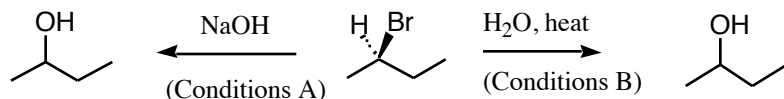
7. Show the Starting Alkyl Bromide which gave the following products.



8. Show an alkyl bromide and some nucleophile that you could use to make the following. (I don't care whether you specify a nucleophile just as the anion  $Z^-$  or as  $NaZ$  with a metal counterion.)



9. Optically active (R)-2-bromobutane can be converted to 2-butanol under either conditions A or conditions B. Describe the stereochemistry of the product solutions for the two different conditions.

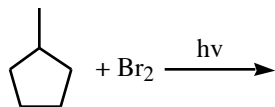


Conditions A

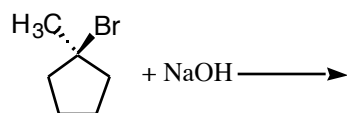
Conditions B

- Alcohol is Chiral or Achiral?
- Optically Active or Not?
- (R), (S), or both?
- Reaction occurred by Inversion, Retention, or Racemization?
- What happens to the rates if you double the concentrations of all reactants?

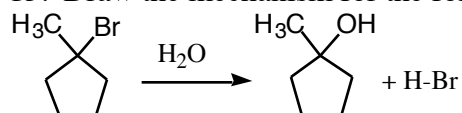
10. Draw the major product for the following reaction. Then draw the mechanism for its formation. (Draw the propagation steps only.) Is your product chiral? (You may need to add relevant hydrogens.)



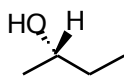
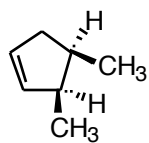
11. Draw the major product for the following reaction. Then draw the mechanism for its formation. (You may need to add relevant hydrogens.)



13. Draw the mechanism for the following reaction. (Don't worry about designating stereochem.)



14. Classify each of the chiral carbons in the following structures as (R) or (S).

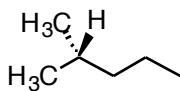
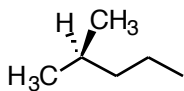
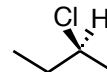
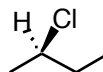
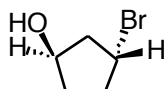
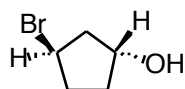


15. Draw (R)-2-bromopentane

16. Draw *meso*-1,3-dichlorocyclopentane, and mark the chiral C's as (R) or (S).

17. Draw all of the different isomers of 2,3-dichlorobutane, identify each as either chiral or *meso*, and classify the relationship between each two as enantiotopic or diastereotopic. (You may use Fischer projections or zig/zag/hash/wedge pictures, as you please. (If two are the same, cross one of them off your list.)

18. Classify the pairs of molecules as diastereomers, enantiomers, or same. For the first molecule in each pair, circle it if it is chiral. For the second molecule in each pair, put a \* next to each chiral C.



JASPERSE CHEM 350 TEST 2

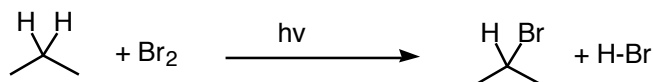
VERSION 4

Ch. 4 The Study of Chemical Reactions

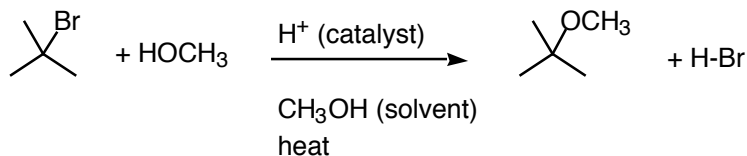
Ch. 5 Alkyl Halides: Nucleophilic Substitution and Elimination

Ch. 6 Stereochemistry

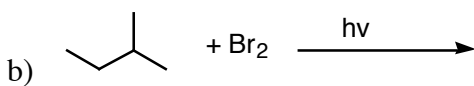
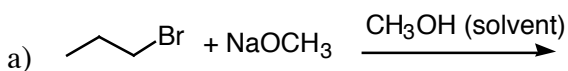
1. Draw the mechanism for the following reaction, and write “slow” next to the rate-determining step. Be sure to draw all intermediates, and to correctly draw “electron-movement” arrows or half-arrows. (Show the propagation steps only.) (4 points)

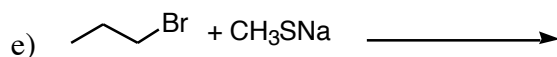
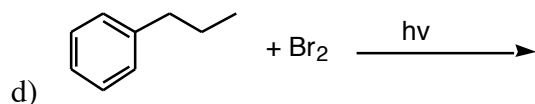
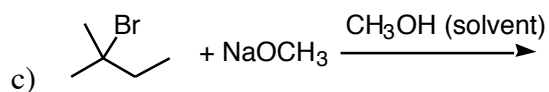


2. Draw the mechanism for the following reaction, and write “slow” above the rate-determining step. Be sure to draw all intermediates, and to correctly draw “electron-movement” arrows. (5 points)

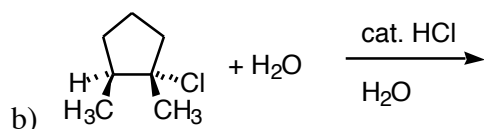
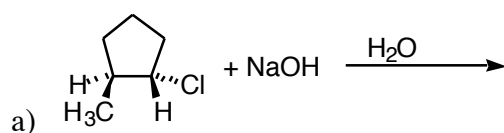


3. Predict the major products for the following reactions. (4 points each)

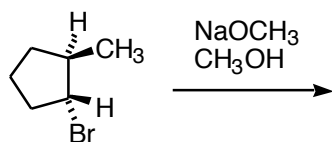




4. Draw the substitution products for the following reactions. (Do not draw the accompanying elimination products). Include stereochemistry in your answer, and if two substitution products are formed draw them both. (4 points each)



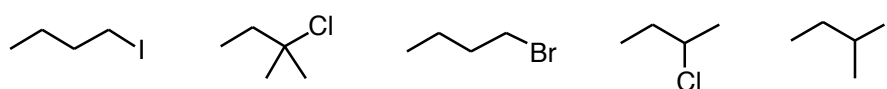
5. Draw the E2 elimination product(s) [do not draw the substitution product(s)]. (4 points each)



6. Of the following alkyl halides, (3 points)

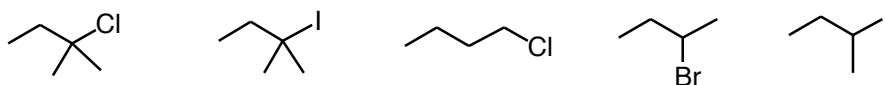
a) Circle the one that would be the most reactive toward  $S_N2$  substitution

b) Put a box around the one that would be the least reactive toward  $S_N2$  substitution





7. Of the following alkyl halides, (3 points)  
 c) Circle the one that would be the most reactive toward  $S_N1$  substitution  
 d) Put a box around the one that would be the least reactive toward  $S_N1$  substitution



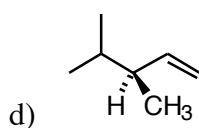
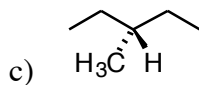
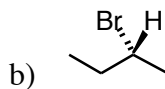
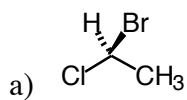
8. Rank the stability of the following carbocations, from 1 (most stable) to 4 (least stable) (4 pts)



9. Rank the stability of the following radicals, from 1 (most stable) to 4 (least stable) (4 pts)

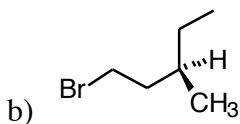


10. Classify as R or S (2 pts each)

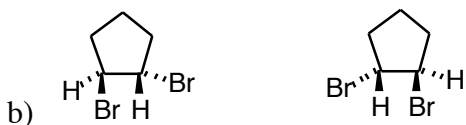


11. Provide the structure and the IUPAC name for the following (3 pts each)

a) (R)-3-chloro-2-methylheptane



12. Classify the pairs of molecules as not isomers, structural isomers, diastereomers, enantiomers, or identical, and circle any molecules that are achiral. (2 pts each)



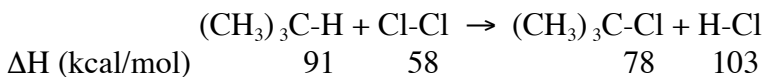
13. For 1,2-dimethylcyclopentane, (8 pts)

a) How many stereocenters are present

b) Draw all the possible stereoisomers, and circle those that are chiral.

Each of the following multiple choice problems is worth 3 points.

14. For the reaction shown below, with bond dissociation energies listed below each key bond, the overall  $\Delta H$  is:

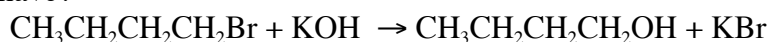


- a) +58 kcal/mol
- b) -32 kcal/mol
- c) +32 kcal/mol
- d) -57 kcal/mol
- e) +181 kcal/mol

15. Which factor would not increase the rate of an E1 reaction:

- a) Use of a more polar solvent
- b) Use of a 3° rather than a 2° alkyl halide
- c) Doubling the concentration of the base
- d) Using iodide rather than bromide as leaving group

16. Consider the  $\text{S}_\text{N}2$  reaction shown below. Assuming no other changes, what effect on the rate would simultaneously doubling the concentrations of both 1-bromobutane and KOH have?



- a) No effect
- b) It would double the rate
- c) It would triple the rate
- d) It would increase the rate by four times
- e) It would increase the rate six times

17. Of the  $\text{S}_\text{N}1/\text{S}_\text{N}2/\text{E}1/\text{E}2$  reactions, rearrangements are likely to occur in:

- a)  $\text{S}_\text{N}1$  reactions only
- b)  $\text{S}_\text{N}2$  reactions only
- c) E1 reactions only
- d) Both  $\text{S}_\text{N}1$  and E1 reactions
- e) Both  $\text{S}_\text{N}2$  and E2 reactions



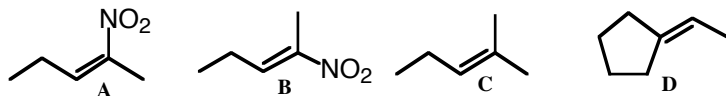
JASPERSE CHEM 350 TEST 3  
 Ch. 7 Structure and Synthesis of Alkenes  
 Ch. 8 Reactions of Alkenes

VERSION 1

1. How many elements of unsaturation are in the formula  $C_6H_9NO_2$ ? (3 points)

- a. 0 b. 1 c. 2 d. 3 e. 4 f. 5 g. 6

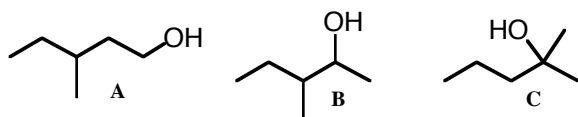
2. For the three structures shown, which of the statements is true? (3 points)



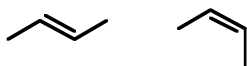
- a. A, C, and D are Z; B is E  
 b. A and B are the only Z compounds  
 c. A is the only Z compound; B is the only E compound  
 d. B, C, and D are Z; A is E  
 e. B is the only Z compound; A is the only E compound

3. Rank the reactivity of the following toward  $H_2SO_4/\hat{I}$  catalyzed dehydration. (3 points)

- a. A is fastest; C is slowest  
 b. B is fastest; C is slowest  
 c. A is fastest; B is slowest  
 d. C is fastest; B is slowest  
 e. B is fastest; A is slowest  
 f. C is fastest; A is slowest

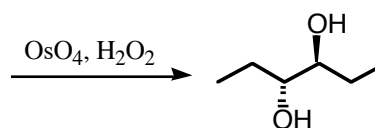


4. Which of the following reactants would give exactly the same products from both (E)- and (Z)-2-butene? (3 points)

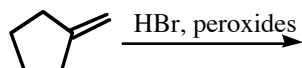
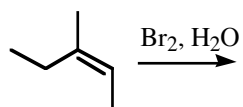
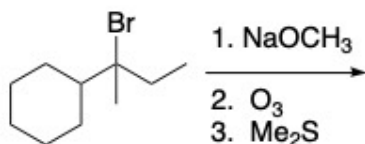
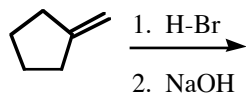
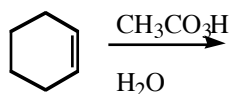
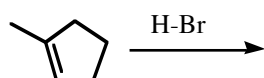
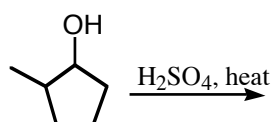
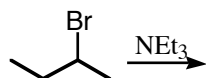
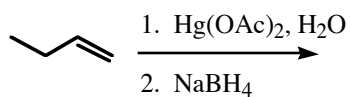


- a.  $Br_2$   
 b.  $PhCO_3H$   
 c. 1)  $BH_3$ -THF 2)  $NaOH, H_2O_2$   
 d.  $OsO_4, H_2O_2$   
 e.  $D_2, Pt$

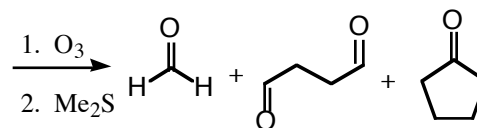
5. Draw the alkene that gives the product shown, and specify its stereochemistry. (2 points)



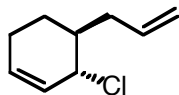
6. Draw the **major** product for each of the following reactions or reaction sequences. You needn't bother to show side products or minor products. For chiral molecules that are racemic, you needn't draw both enantiomers. BE CAREFUL TO SHOW THE CORRECT ORIENTATION, AND THE CORRECT STEREOCHEMISTRY IN CASES WHERE STEREOCHEM IS FACTOR. (3 points each)



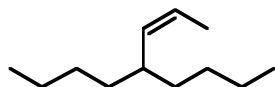
7. A single unknown reacts with  $\text{O}_3/\text{Me}_2\text{S}$  to give the following three products. What is the structure for the unknown? (3 points)



8. Provide the name or structure for the following. (3 points each)



(racemic, don't do R/S stuff)



9. Provide a possible structure for a compound with formula  $\text{C}_5\text{H}_8$ , given that it reacts with excess  $\text{H}_2/\text{Pt}$  to give  $\text{C}_5\text{H}_{10}$ . (3 points)

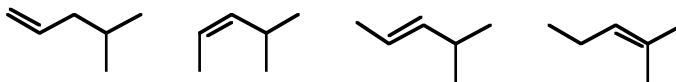
10. Fill in the blanks for the following reaction sequence: (6 points)



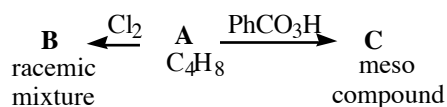
11. Consider how the Se-O bond would be polarized and predict the product which would result when  $\text{CH}_3\text{SeOH}$  adds to propene: (Selenium is located two rows directly below oxygen on the periodic table). (3 points)



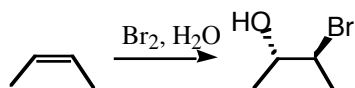
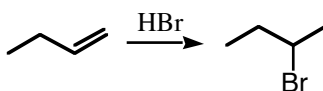
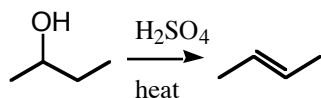
12. When the following isomeric alkenes are fully burned, rank the amount of heat produced in the combustions, from most heat produced (1) to least heat produced (4). (3 points)



13. Provide structures for starting material **A** and reactions products **B** and **C**, given the formula of starting material **A** and the stereochemical status of products **B** and **C**. (5 points)



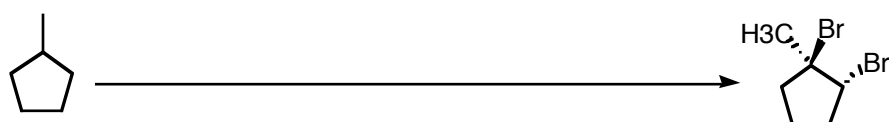
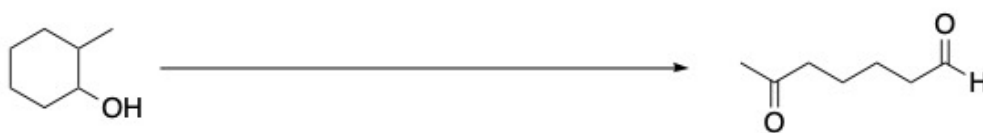
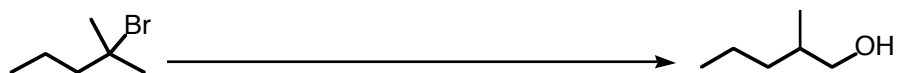
14. Draw mechanisms for the following reactions, using formal arrow-pushing. Each intermediate along the mechanism pathway must be shown. (6 points, 3 points, 6 points)



(be sure your mech. is consistent with the observed stereochemistry)



15. Provide reagents for the following transformations. (5 points each)





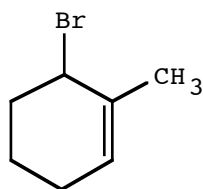
JASPERSE CHEM 350 TEST 3  
Ch. 7 Structure and Synthesis of Alkenes  
Ch. 8 Reactions of Alkenes

## VERSION 2

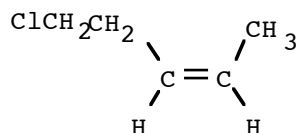
1. How many elements of unsaturation are in the formula  $C_8H_9N$ ?

- a. 0
- b. 1
- c. 2
- d. 3
- e. 4
- f. 5

2. Provide the proper IUPAC name for the alkene shown below.



3. Provide the proper IUPAC name for the alkene shown below.



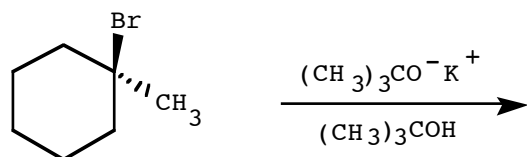
4. Draw an acceptable structure for 4-phenyl-1-butene.

5. Draw the alkene of formula  $C_4H_8$  which evolves the most heat per mole upon hydrogenation

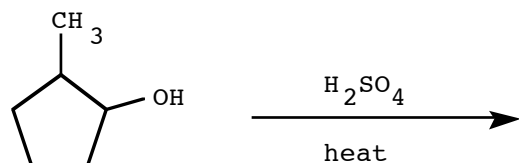
6. Choose the most stable alkene among the following.

- a. 1-hexene
- b. (E)-2-hexene
- c. (Z)-2-hexene
- d. They are all of equal stability according to Saytzeff's rule.

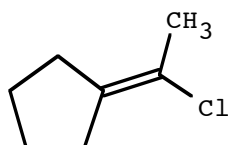
7. Draw the major product of the following reaction.



8. Draw the major product and the mechanism.



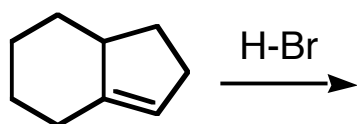
9. Which of the following best describes the geometry about the carbon-carbon double bond in the alkene below?



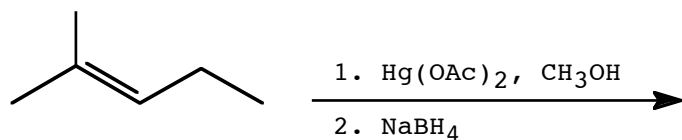
- a. E
- b. Z
- c. Neither E nor Z

10. Draw 3 examples of molecules with the formula  $\text{C}_4\text{H}_6\text{O}_2$ .

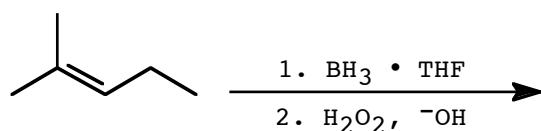
11. Draw the major product.



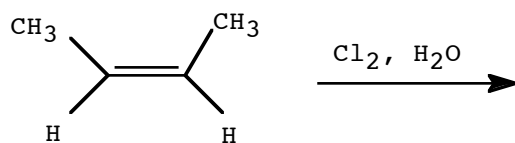
12. Draw the major product.



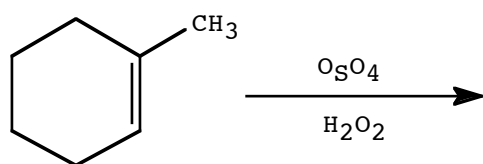
13. Draw the major product.



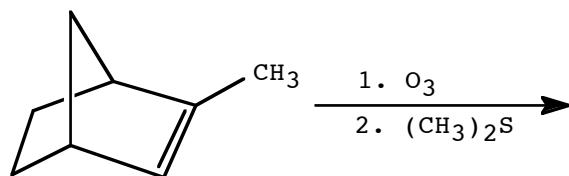
14. Draw the major product.



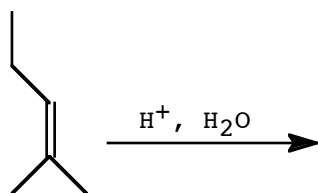
15. Draw the major product.



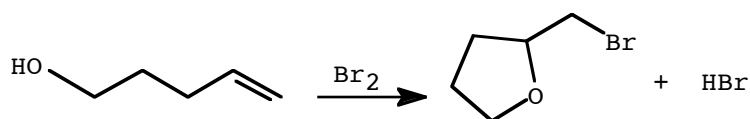
16. Draw the major product.



17. Complete the following reaction and provide a detailed, step-by-step mechanism for the process.

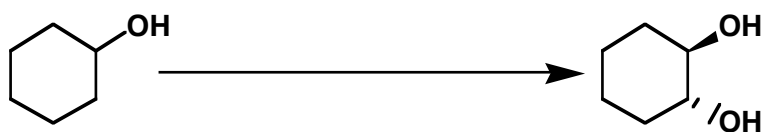


18. Suggest a reasonable detailed, step-by-step mechanism for the reaction shown below.



This one is very hard. It's a challenge problem. Kind of an extension using ideas from class but pushing a little bit beyond what was covered. Few students got this one correct.

19. Provide the reagents necessary to complete the following transformation. (2 steps minimum).

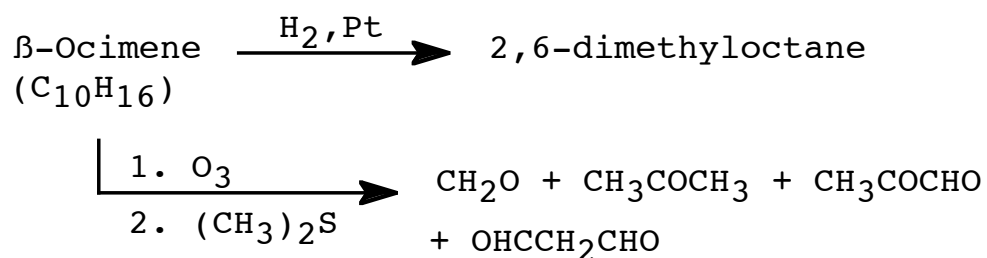


20. Both (E)- and (Z)-3-hexene can be treated with  $\text{D}_2$  in the presence of a platinum catalyst. How are the products from these two reactions related to each other?

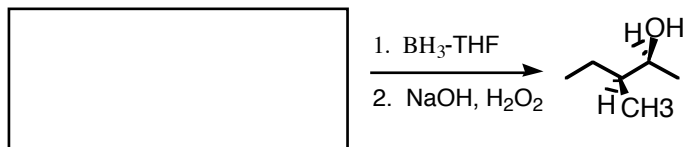
- The (E)- and (Z)-isomers generate the same products in exactly the same amounts.
- The (E)- and (Z)-isomers generate the same products but in differing amounts.
- The products of the two isomers are related as diastereomers.
- The products of the two isomers are related as enantiomers.
- The products of the two isomers are related as structural isomers.

21. Consider how the I-Cl bond is polarized and predict the product which results when this mixed halogen adds to 1-methylcyclohexene.

22.  $\beta$ -Ocimene is a perfume. Suggest a possible structure for  $\beta$ -ocimene that is consistent with the following information.



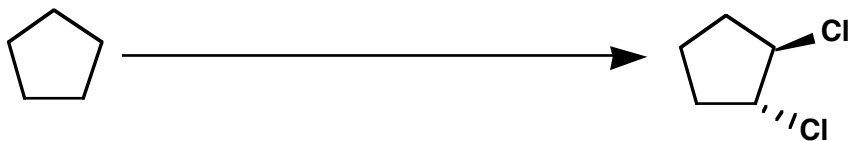
23. Fill in the starting reactant.



24. Fill in the blanks for the following reaction sequence.



25. Provide reagents to carry out the following transformation: (3 steps minimum)





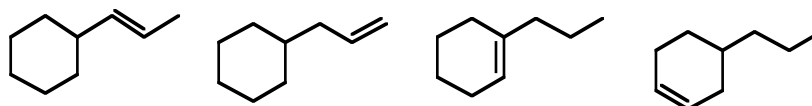


JASPERSE CHEM 350 TEST 3  
Ch. 7 Structure and Synthesis of Alkenes  
Ch. 8 Reactions of Alkene

## VERSION 3

The number of points per problem is indicated in parentheses following each problem.

1. Rank the following alkenes in order of stability, 1 being most stable, 4 being least stable. (4)

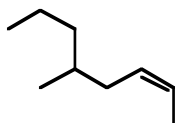


2. Determine the number of elements of unsaturation for  $C_5H_7ClO$ . (3)

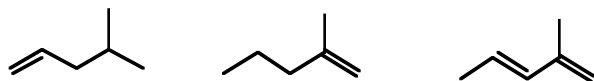
3. Give the proper IUPAC name or the structure for the following compounds. (4 points each)

- a. (E)-2-chloro-3-methyl-2-pentene

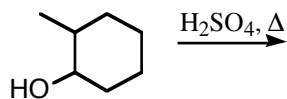
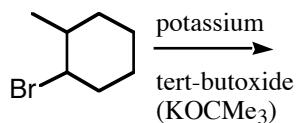
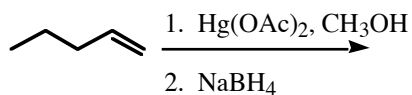
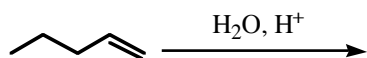
b.



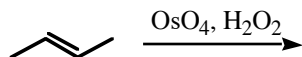
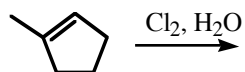
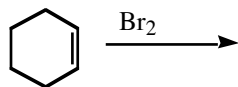
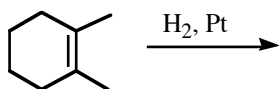
4. Rank the reactivity of the following alcohols towards HBr, 1 being the fastest reactant, 3 being the slowest reactant. (3 points)



5. Predict the major product for the following reactions. You needn't bother to show any side products or minor products. Pay careful attention to orientation. (3 points each)



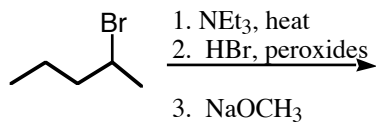
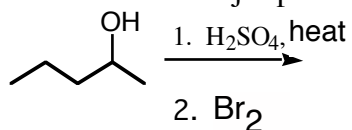
6. Predict the major product in each of the following reactions. Pay careful attention to stereochemistry! (3 points each)



7. Fill in the starting reactant. (4 points each)



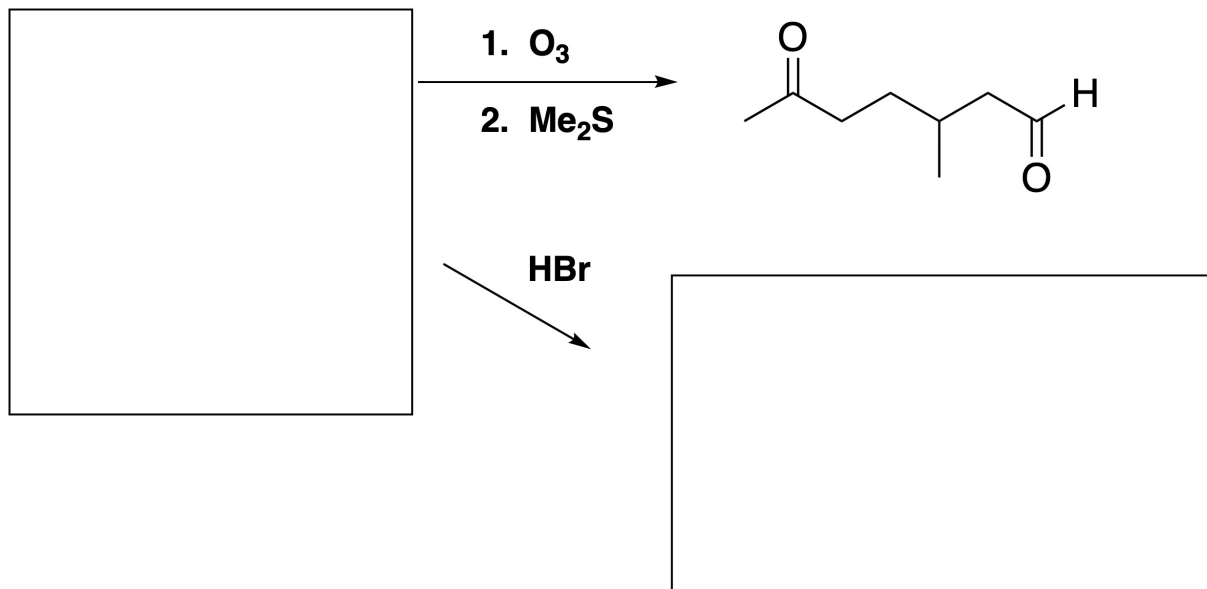
8. Provide the major product of the following reaction sequences. (4 points each)



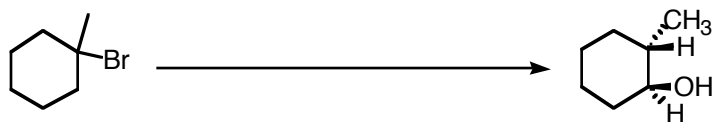
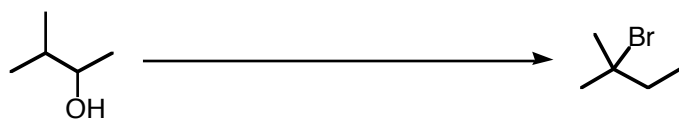
9. What is a possible structure for a molecule **A** given the following: (6 points)

- is has the formula  $C_6H_{10}$
- it reacts with  $H_2/Pt$  to give a product with formula  $C_6H_{12}$
- upon ozonolysis ( $O_3$ ;  $Me_2S$ ) it gives two products,  $CH_2=O$  and a product  $C_5H_8O$ .

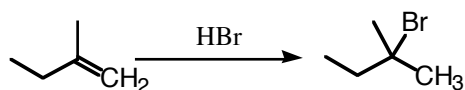
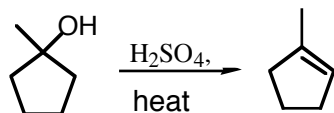
10. Fill in the boxes. (6 points total)



11. Provide reagents to accomplish the following transformations. (6 points each)



12. Draw the mechanisms for the following reactions. Be sure to draw all intermediates, and try to correctly draw "electron-movement" arrows. (8 points for the first, 6 points for the second)



13. Draw as many isomers as you can for alkenes with formula  $\text{C}_5\text{H}_{10}$ . (8 points. 2 points off for each duplicate or each possible isomer not drawn.)



JASPERSE CHEM 350 TEST 3  
Ch. 7 Structure and Synthesis of Alkenes  
Ch. 8 Reactions of Alkenes

## VERSION 4

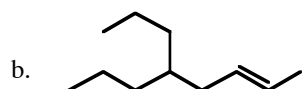
1. Rank the following alkenes in order of stability, 1 being most stable, 4 being least stable. (3 points)



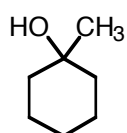
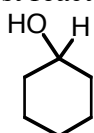
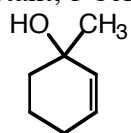
2. Determine the number of elements of unsaturation for  $C_5H_8O$ . (2 points)

3. Give the proper IUPAC name or the structure for the following compounds. (3 points each)

a. 4-vinylcyclopentene

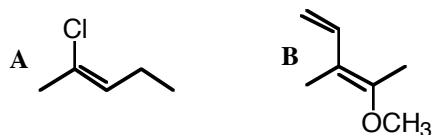


4. Rank the reactivity of the following alcohols towards  $H_2SO_4/\Delta$  catalyzed dehydration, 1 being the fastest reactant, 3 being the slowest reactant. (3 points)

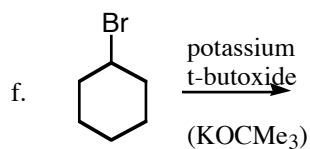
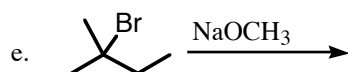
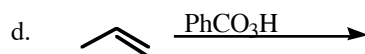
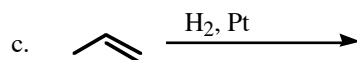
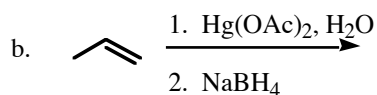


5. Which of the following statements is true for the structures shown: (3 points)

- a. **A** is Z and **B** is Z
- b. **A** is Z and **B** is E
- c. **A** is E and **B** is Z
- d. **A** is E and **B** is E

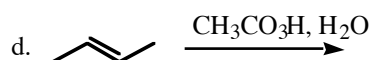
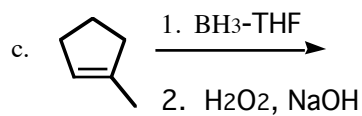
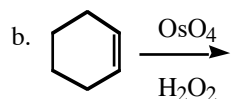
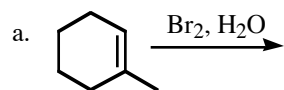


6. Predict the major product for the following reactions. You needn't bother to show any side products or minor products. Pay careful attention to orientation, which is important in many of these problems. (3 points each)

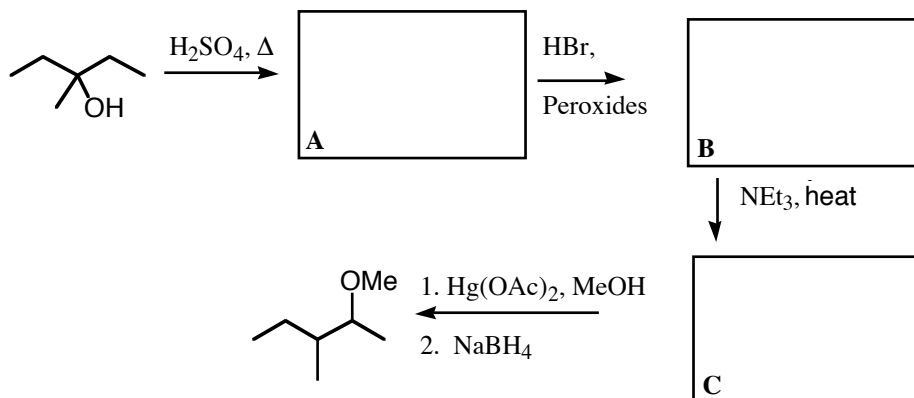




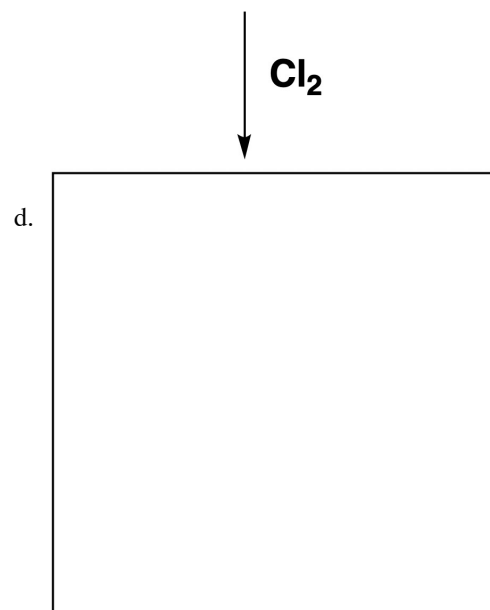
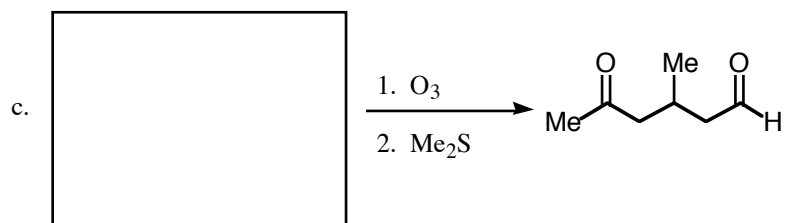
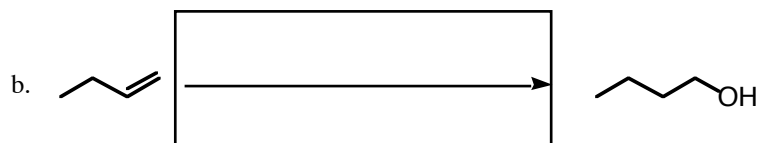
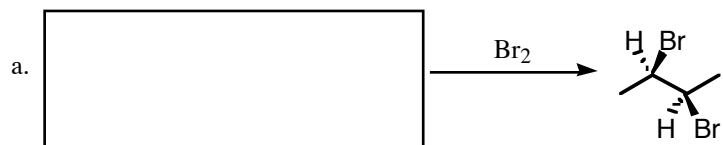
7. Predict the major product in each of the following reactions. Pay careful attention to stereochemistry: stereochemistry is involved in each of these problems! (3 points each)



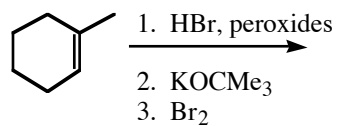
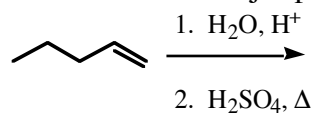
8. Fill in the intermediates in the following transformation. (3 points each)



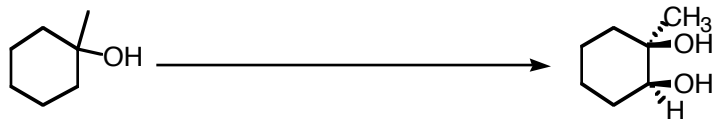
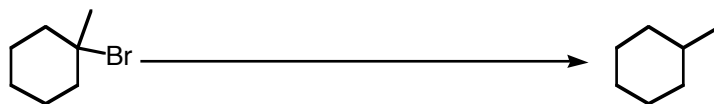
9. For the following reactions, fill in the missing starting materials, reagents, or products. (3 points each)



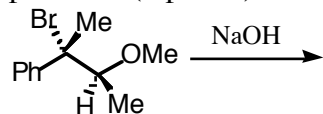
10. Provide the major product of the following reaction sequences. (4 points each)



11. Provide reagents to accomplish the following transformations. (4 points each)

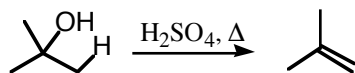


12. Provide the product for the following reaction. Be sure to show the stereochemistry of the product. (3 points)

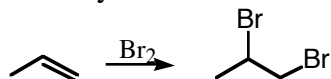


This is a really tricky one.  
Don't stress too much about it.

13. Draw the mechanism for the following reaction, and write "slow" next to the rate determining step. Be sure to draw all intermediates, and to correctly draw "electron-movement" arrows or half-arrows. (4 points)



14. Draw the mechanism for the following reaction. Be sure to draw all intermediates, and to correctly draw "electron-movement" arrows or half-arrows. (4 points)



15. Formula:  $\text{C}_4\text{H}_8$

Reactivity: reacts with  $\text{H}_2/\text{Pt}$  to give  $\text{C}_4\text{H}_{10}$

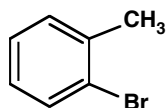
DRAW ALL POSSIBLE ISOMERS, INCLUDING STEREOISOMERS. (4 isomers are possible!) (5 points)

JASPERSE CHEM 350 TEST 4 VERSION 1  
 Conjugation, Diels-Alder, Aromaticity, Aromatic Reactions

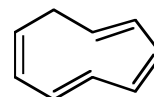
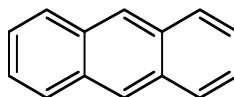
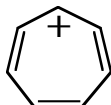
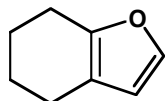
1. Provide the Name or Structure for the Following (7 points)



m-nitroaniline

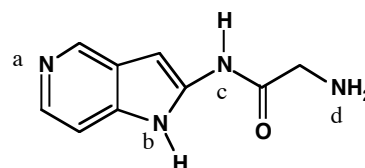


2. Circle the aromatic molecules (6 points)

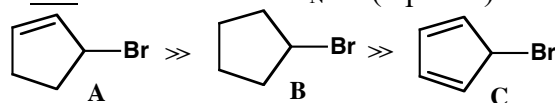


3. For each nitrogen in the molecule, classify the hybridization of the nitrogen atom, the hybridization of the nitrogen lone pair, and classify whether the basicity of the nitrogen is “normal” or “low”. (5 points)

|                | Nitrogen<br>Hybridization | Lone-Pair<br>Hybridization | Nitrogen<br>Basicity |
|----------------|---------------------------|----------------------------|----------------------|
| N <sub>a</sub> |                           |                            |                      |
| N <sub>b</sub> |                           |                            |                      |
| N <sub>c</sub> |                           |                            |                      |
| N <sub>d</sub> |                           |                            |                      |

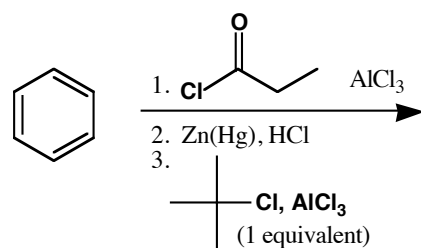
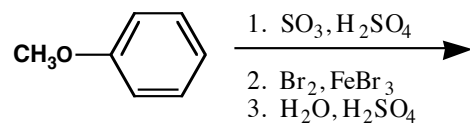
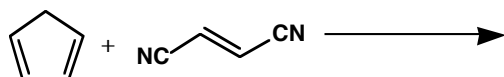
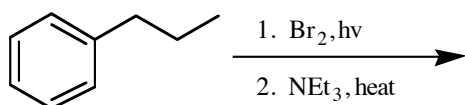
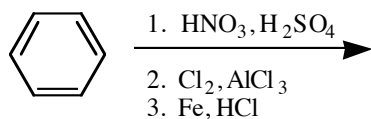
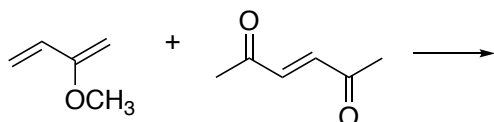
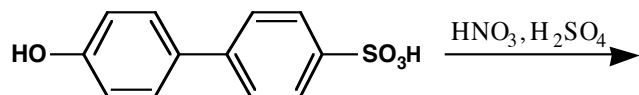


4. Bromide **B** has normal reactivity (for a 2° bromide) toward S<sub>N</sub>1 substitution, but **A** has much higher reactivity and **C** has much lower reactivity. a) Why is **A** more reactive toward S<sub>N</sub>1? b) Why is **C** much less reactive toward S<sub>N</sub>1? (4 points)

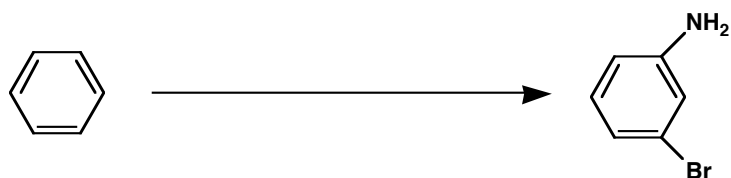
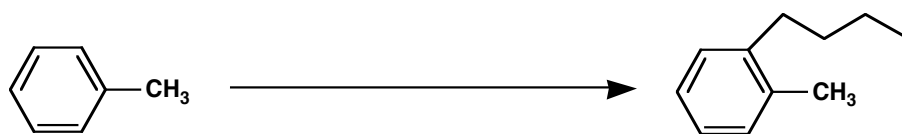


Kinetic reactivity toward  
 S<sub>N</sub>1 reactivity (H<sub>2</sub>O, H<sup>+</sup>)

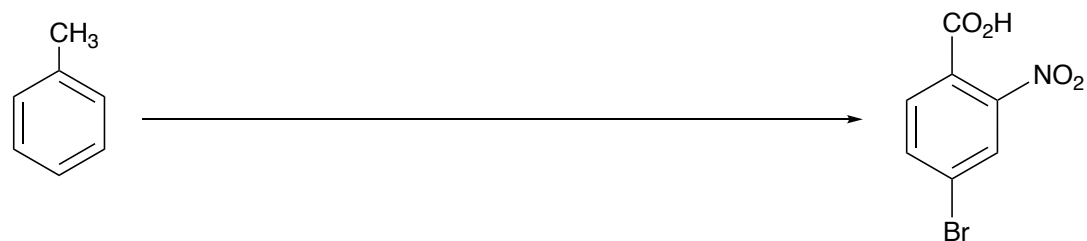
5. Synthesis Reactions. Draw the feature product of the following reactions (need not show any byproducts). (21 points, 3 points each)



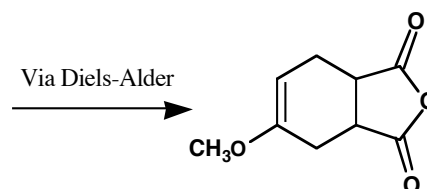
6. Design sequences for the designated conversions. (5 points each)



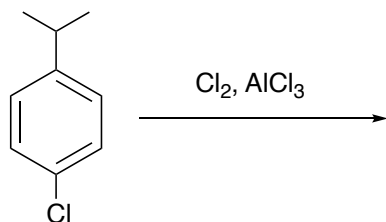
7. Design a synthesis for the following molecule beginning with toluene. (6 points)



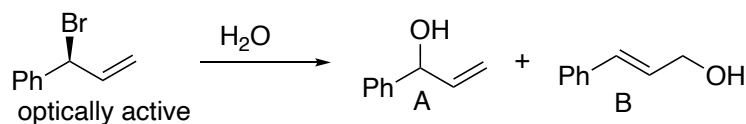
8. Draw the Reactants for the following (3 points)



9. a) Draw the major product for the following reaction, and b) draw the mechanism for its formation. c) Identify the slow step. d) Draw all the resonance structures for the cation intermediate. (7 points)



10. (9 points total) a) Draw the mechanism for the following reaction, in which a common intermediate gives rise to both products.



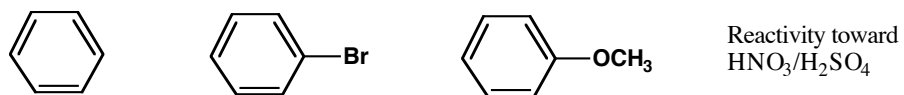
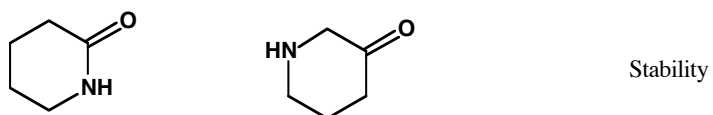
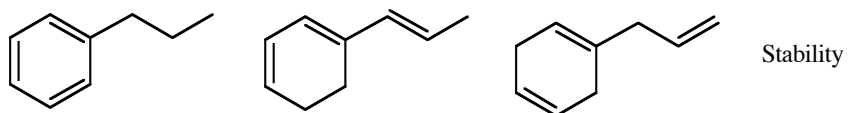
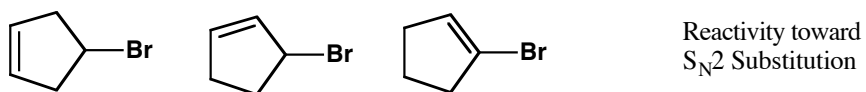
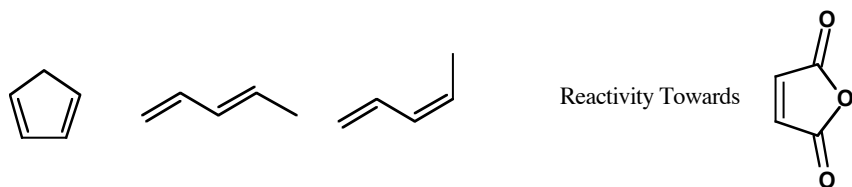
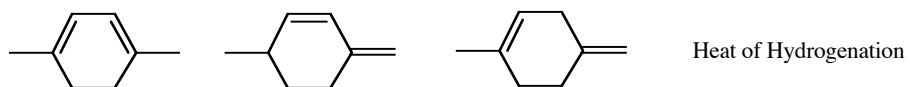
b) In the above reaction, is product A chiral or achiral?

c) Which is the "thermodynamic" product (more stable, which builds up under equilibrating conditions)?

d) You probably already did this, but either re-draw or identify the two key resonance structures for the intermediate in the mechanism above. (You can just circle the two of them, assuming you already sketched them above.).



11. Rank the following, with 1 being highest/most. (2 points each)



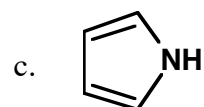


JASPERSE CHEM 350 TEST 4 VERSION 2  
 Conjugation, Aromatic Compounds, Reactions of Aromatic Compounds

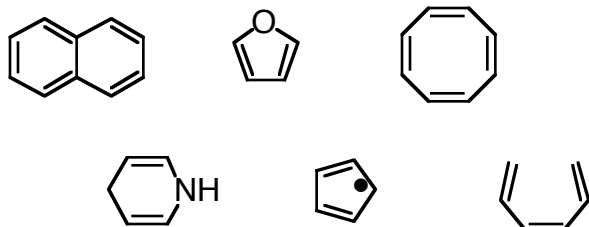
1. Provide the Name of Structure for the following. (7 points)

a. 3-nitroaniline

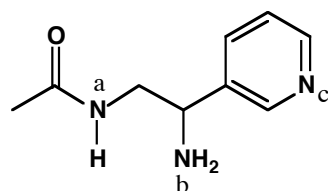
b. o-isopropyltoluene



2. Circle the aromatic molecules. (7 points)



3. The molecule has 3 different nitrogens. For each of them, classify the hybridization of the nitrogen atom, the hybridization of the nitrogen lone pair, and whether the basicity of the nitrogen is "normal" or "low". (6 points)



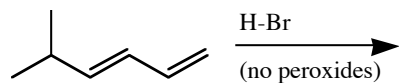
| <u>Nitrogen</u><br><u>Hybridization</u> | <u>Lone-Pair</u><br><u>Hybridization</u> | <u>Nitrogen</u><br><u>Basicity</u> |
|---|--|------------------------------------|
|---|--|------------------------------------|

N<sup>a</sup>

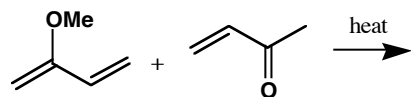
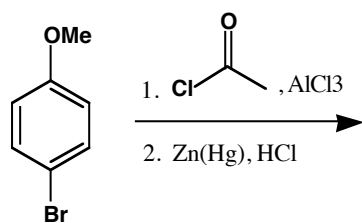
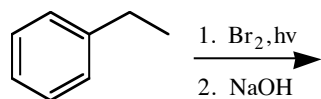
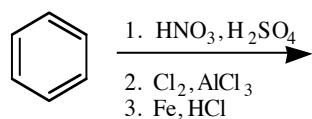
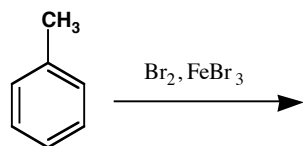
N<sup>b</sup>

N<sup>c</sup>

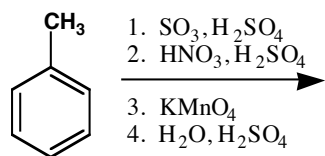
4. Draw the major products of the following reaction (4 points).



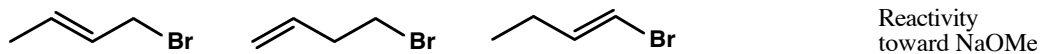
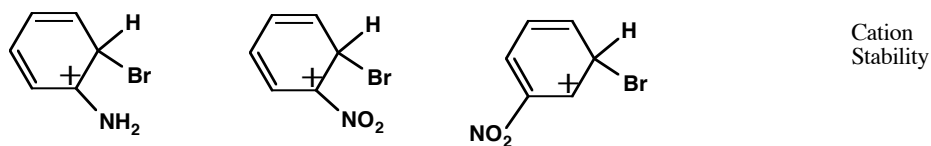
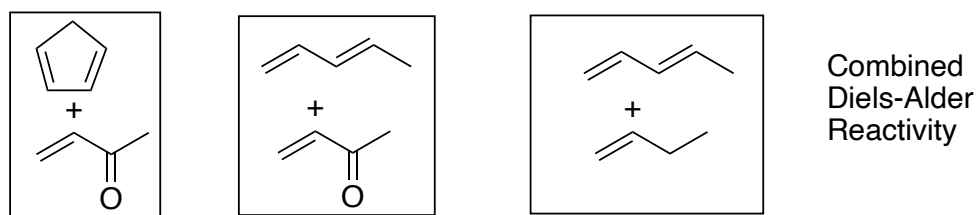
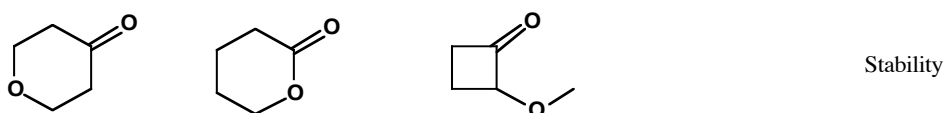
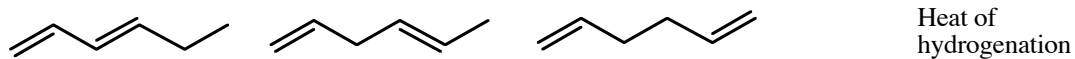
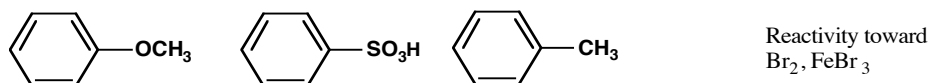
5. Draw the Major Product of the Following Reactions. Note: I want one major product in each case. (3 points each)



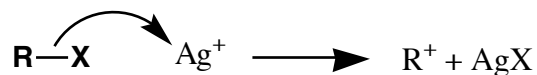
Note: Either of two structural isomers is acceptable as answer



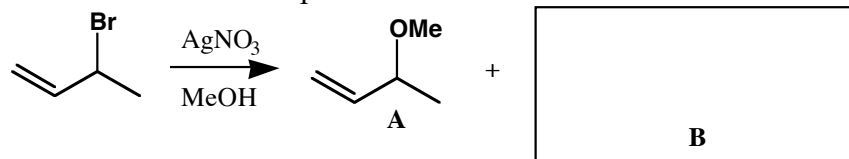
6. Rank the following, with 1 being highest/most. (2 points each)



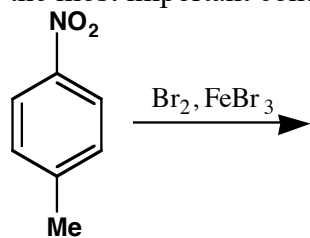
8. Treatment of an alkyl halide with methanolic  $\text{AgNO}_3$  often promotes ionization, via the following:



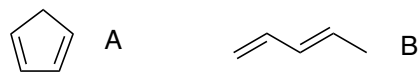
When 3-bromo-1-butene undergoes this reaction, two isomeric products **A** and **B** are formed. Draw the structure for product **B** and the detailed mechanism for formation of product **B**. (7 pts)



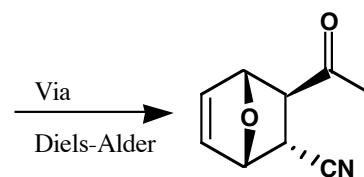
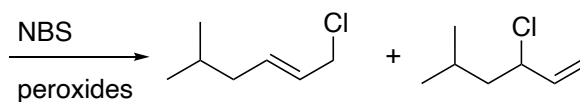
9. Draw the product for the following reaction and draw the mechanism for its formation. Identify the slow step. Draw all the resonance structures for the cation intermediate and circle the most important contributor. (7 points)



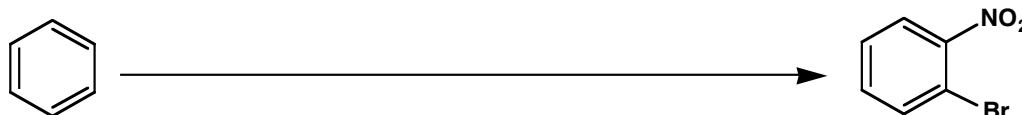
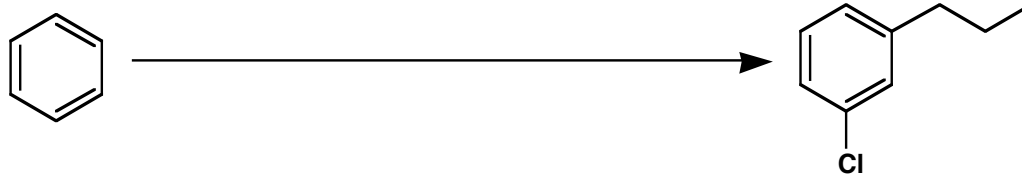
10. (3 pt) When comparing cyclopentadiene (**A**) versus 1,3-pentadiene ( $\text{CH}_2=\text{CH}-\text{CH}=\text{CH}-\text{CH}_3$ , **B**), one is much more acidic. Circle the more acidic chemical, and explain why it is much more acidic.



11. Draw the Reactants for the Following Reactions (6 points)



12. Provide reagents for the following transformations. (5 points each)





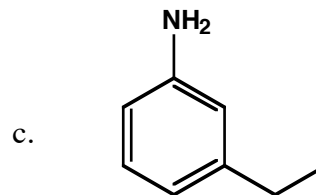


JASPERSE CHEM 350 TEST 4 VERSION 3  
 Conjugation, Aromaticity, Electrophilic Aromatic Substitution

1. Provide Either the Name or the Structure for the Following Chemicals. (6 points) (3 minutes)

a. Furan

b. p-nitrobenzoic acid



2. For the following substituents, classify each as 1) electron-donating or electron-withdrawing ["D" or "W"], 2) as activating or deactivating ["Act" or "Deact"], and as 3) ortho-para directing or meta directing ["o/p" or "m"]. (6 points) (2 minutes)

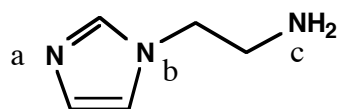


1. D or W

2. Act or Deact

3. o/p or m

3. The molecule below has 3 different nitrogens. For each of the nitrogens, classify the hybridization of the nitrogen atom, the hybridization of the nitrogen's lone pair, and whether the basicity of the nitrogen is "normal" or "low". (6 points, 2 min)



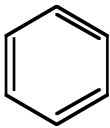
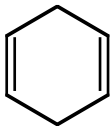
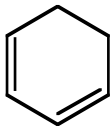
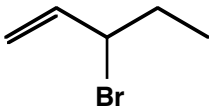
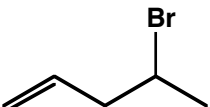
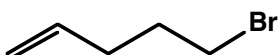
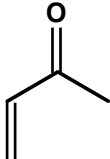
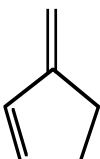
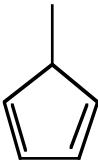
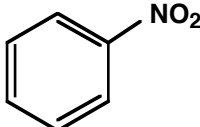
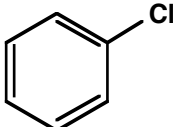
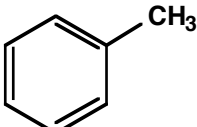
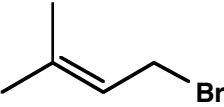
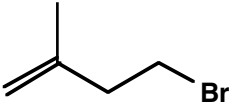
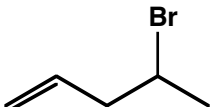
\_\_\_\_\_ Lone-Pair Hybridization \_\_\_\_\_

N<sup>a</sup>

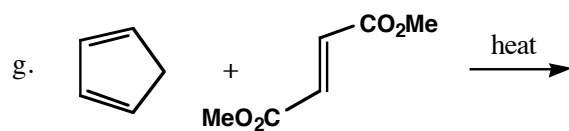
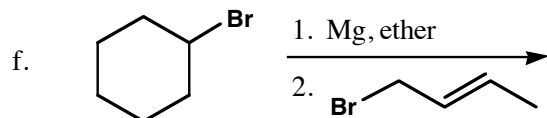
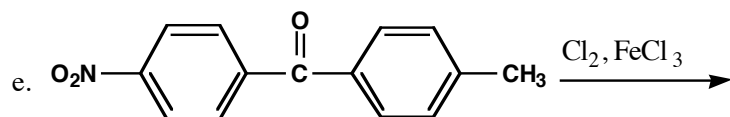
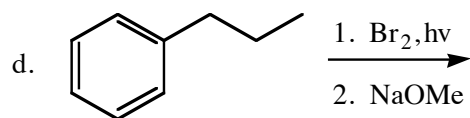
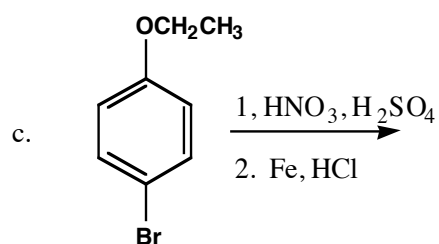
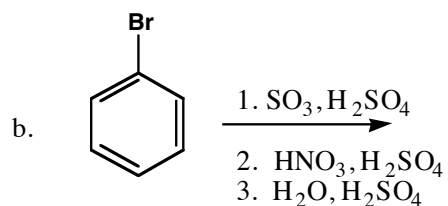
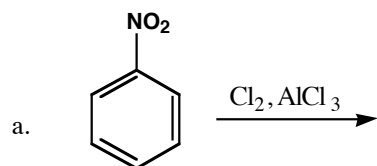
N<sup>b</sup>

N<sup>c</sup>

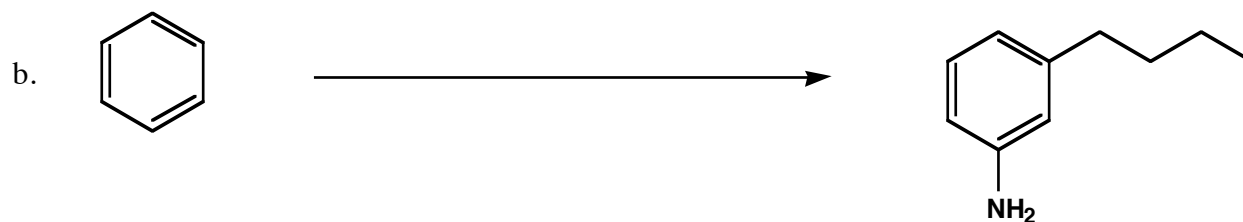
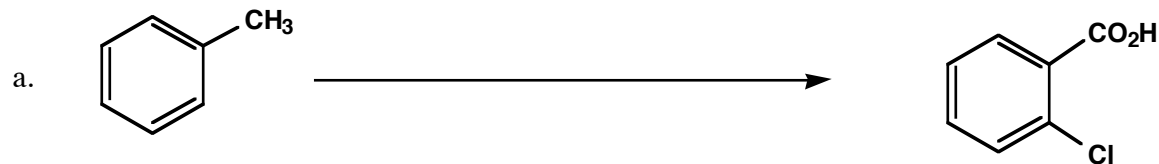
4. Rank the reactivity (rates!) of the following sets of molecules toward the reagents shown, 1 being most reactive, 2 being middle, and 3 being least reactive. (10 points) (6 minutes)

| Reagent  | Molecules Being Compared  |  |   |
|--|---|--|---|
| a. $\text{H}_2, \text{Pt}$   |    |     |    |
| b. $\text{H}^+, \text{H}_2\text{O}$ ( $\text{S}_{\text{N}}1/\text{E}1$ ) |    |    |    |
| c.   |   |    |     |
| d. $\text{HNO}_3, \text{H}_2\text{SO}_4$                                 |  |  |  |
| f. $\text{NaOMe}$<br>( $\text{S}_{\text{N}}2$ reactivity)                |  |  |  |

5. Draw the major product for each of the following reactions. (3 points each, 21 total, 7 minutes)



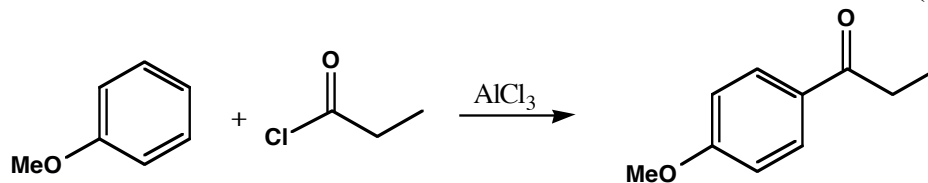
6. Provide reagents for the following transformations. (5 points each, 10 total, 6 minutes)



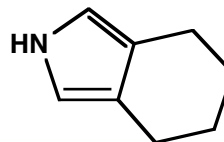
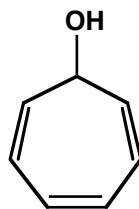
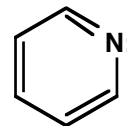
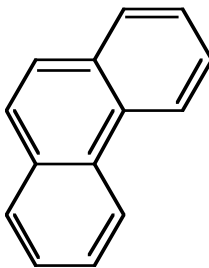
7. Draw the diene and dienophile from which the following Diels-Alder products would have come. (3 points each, 6 total, 2 minutes)



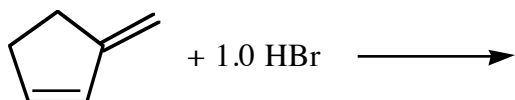
8. a. Draw the mechanism for the formation of the major product shown, and identify the "**slow**" step in the reaction. (6 points, 5 minutes).  
b. Also draw all 4 resonance structures for the cation intermediate in the reaction. (4 points)



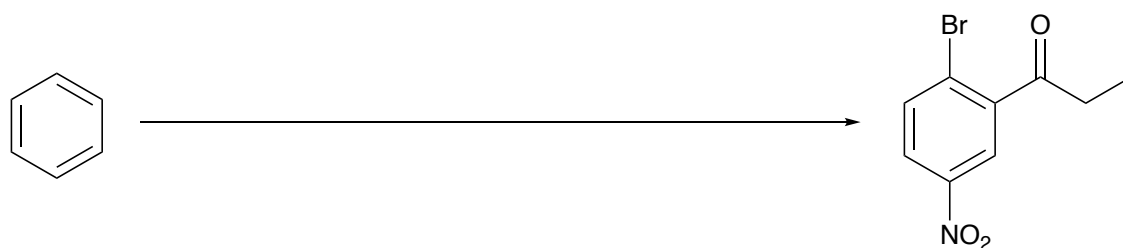
10. Circle the aromatic molecules: (6 points) (3 minutes)



9. Draw the major product or products that would result from the following reaction, and write either "chiral" or "achiral" and "optically active" or "racemic" by each product. Draw a mechanism for the reaction, and identify the "slow" step in the reaction. (8 points, 5 min)



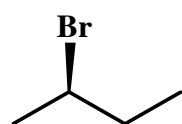
9. Provide a synthesis for the following molecule, starting from benzene and anything else you like. (7 points, 5 min)



JASPERSE CHEM 350 FINAL EXAM  
150 points total

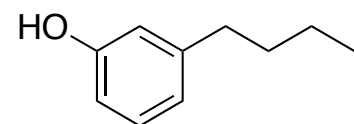
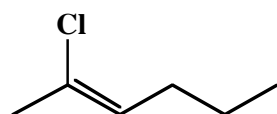
VERSION 1

1. Provide names or structures for the following. 2 points each. Specify stereochemistry when appropriate!

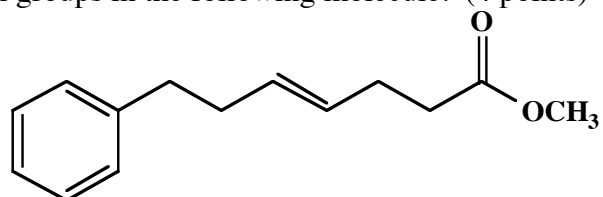


Optically active

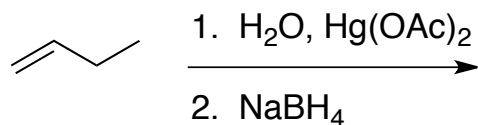
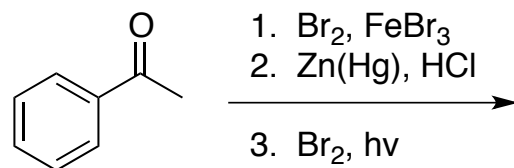
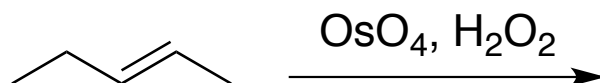
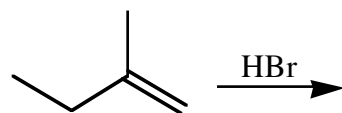
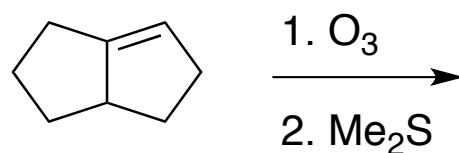
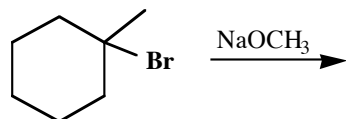
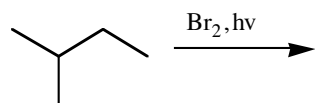
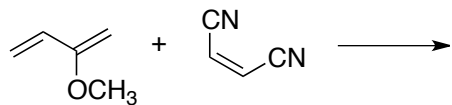
m-isopropylphenol



2. Identify the functional groups in the following molecule. (4 points)

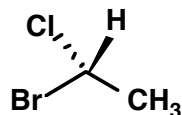
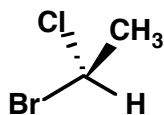
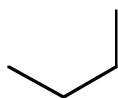
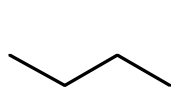
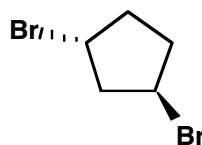
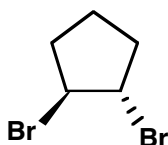
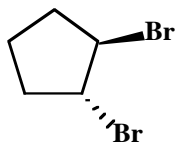
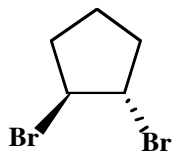


3. Predict the major products for the following reactions. Pay careful attention when orientation is a factor. Draw just one major product in each case. (3 points each)

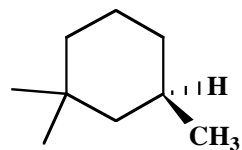
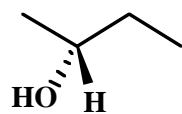




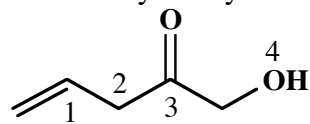
4. Classify the pairs of molecules as totally different, identical, structural isomers, diastereomers, or enantiomers. (2 points each)



5. Classify each chiral carbon as R or S. (2 points each)



6. Classify the hybridization and bond angles (109, 120, or 180) at the labelled atoms. (5 points)



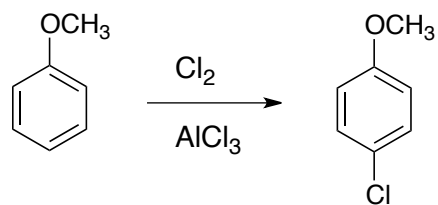
C-1

C-2

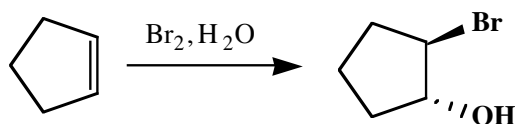
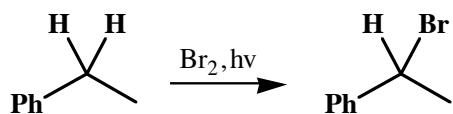
C-3

O-4

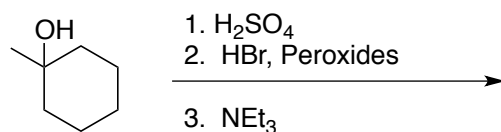
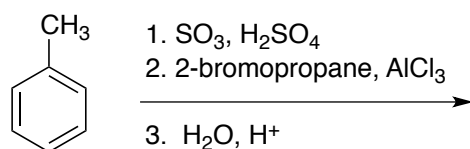
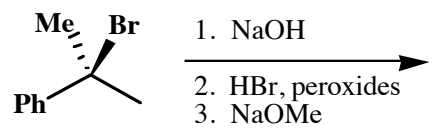
7. Draw the mechanisms for the following reactions. For any radical reactions, draw propagation steps only. 5 points each.



Draw the resonance structures for the cation intermediate.



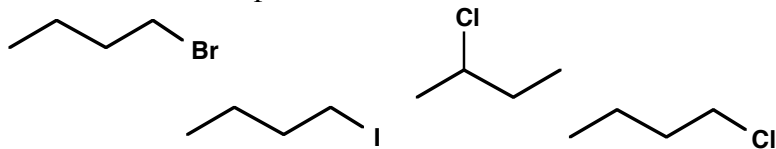
8. Draw the products of the following multi-step sequences. (4 points each)



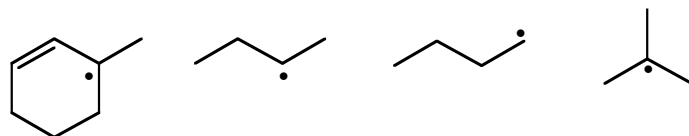
9. Draw as many structural isomers as you can for  $\text{C}_6\text{H}_{14}$ . Circle any that are chiral. (Note: be careful! You will lose points for any repeats!) (6 points)

10. Rank the Following, from most to least. 2 points each.

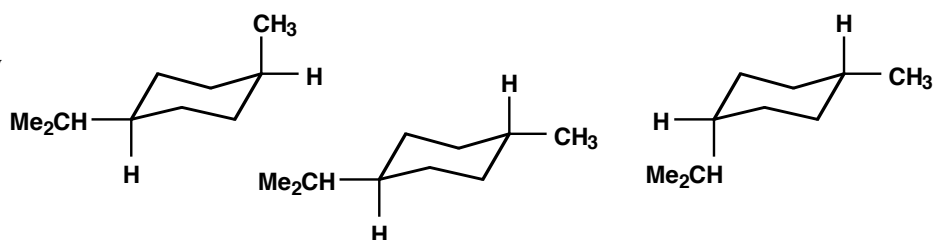
a. Reactivity toward  $S_N2$



b. Stability



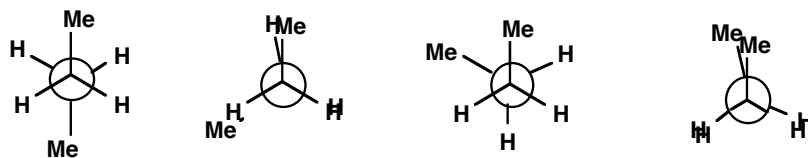
c. Stability



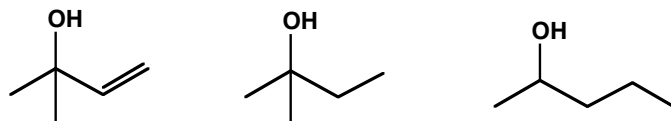
d. Acidity



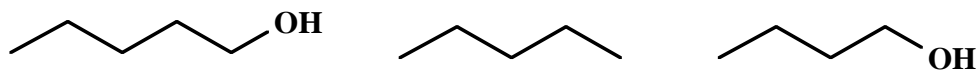
e. Stability



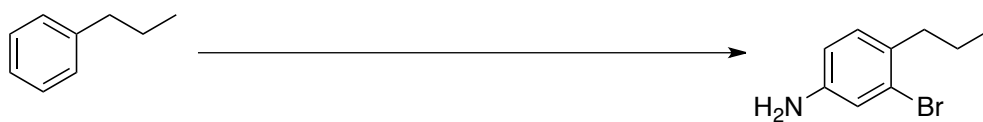
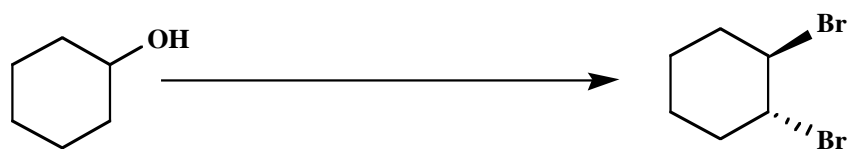
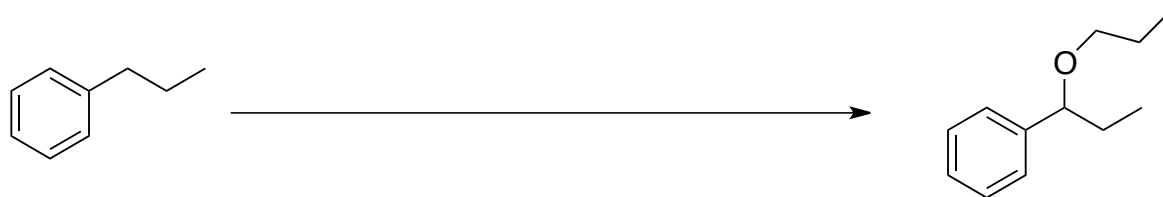
f. Reactivity toward  $\text{H}_2\text{SO}_4/\text{I}^-$  catalyzed dehydration



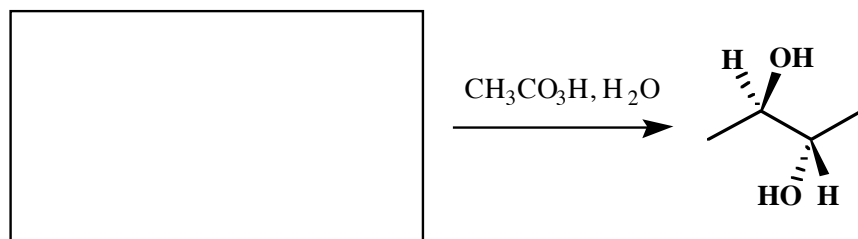
g. Boiling Point



11. Provide reagents for the following transformations. You may use anything you like. Each can be done within  $\leq 3$  steps. (4 points each)



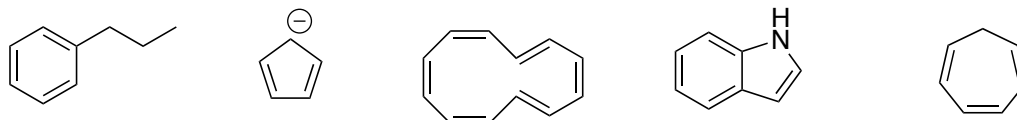
12. Provide the appropriate reactant for the following transformation. (3 points)



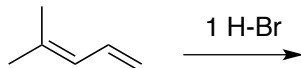
13. Suggest a structure for **X**, given the following info: (5 points)

- Formula:  $C_8H_{12}$
- It Reacts With excess  $H_2/Pt$  to produce  $C_8H_{16}$
- When it reacts with  $O_3/Me_2S$ , one of the products is  $CH_2=O$ .

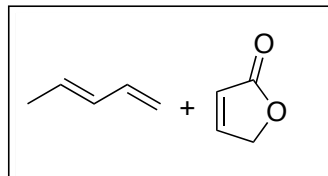
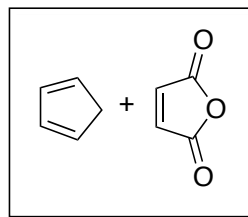
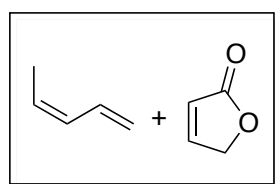
14. Which of the following are aromatic



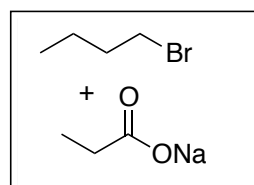
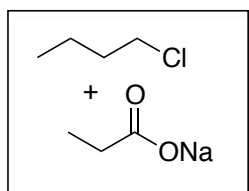
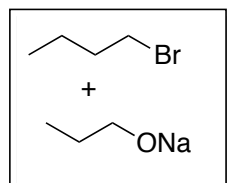
15. Draw the products and mechanism for the following reaction:



16. Rank the following:



Combined  
Diels-Alder  
Reactivity

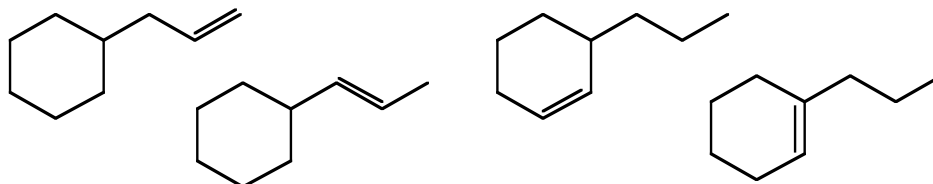


Combined  
 $S_N2$   
Reactivity

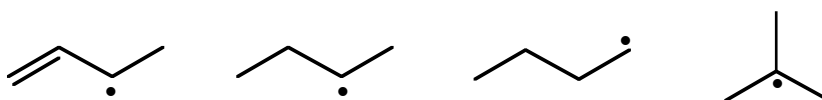
Note: Good for practice, but significantly longer than the real one will be.

1. Rank the Following, from most to least. 2 points each.

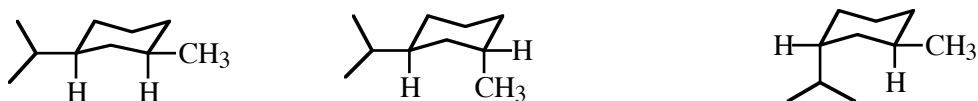
a. Stability



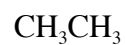
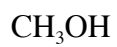
b. Stability



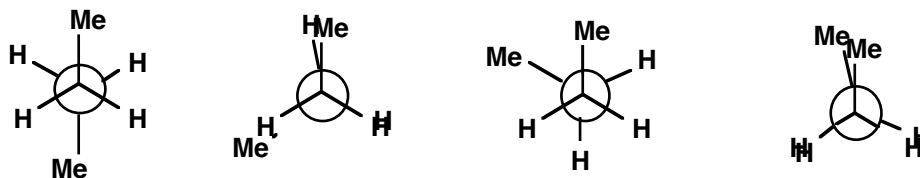
c. Stability



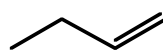
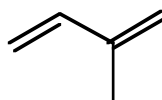
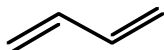
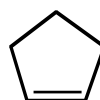
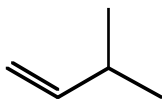
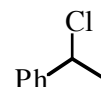
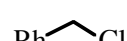
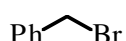
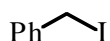
d. Acidity



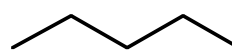
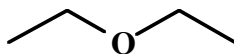
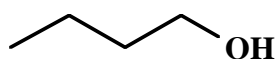
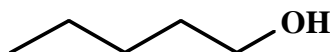
e. Stability



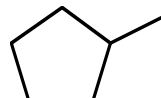
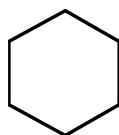
f. Reactivity toward HBr

g. Reactivity toward  $\text{Br}_2/h\nu$ h. Reactivity toward  $\text{S}_{\text{N}}2$ 

i. Boiling Point

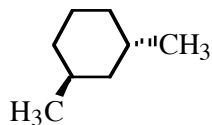


j. Stability

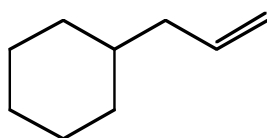


2. Provide names or structures for the following. 3 points each. Note: don't forget to specify stereochemistry!

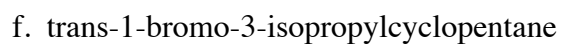
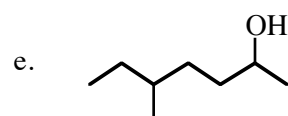
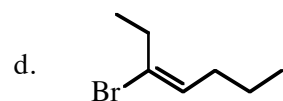
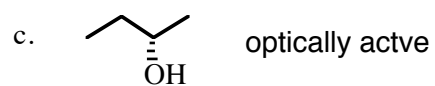
a.



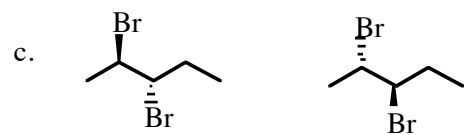
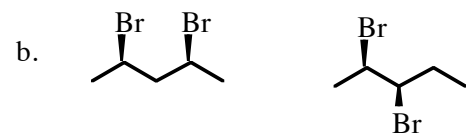
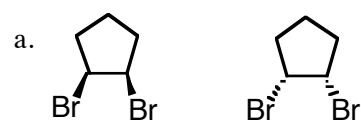
b.



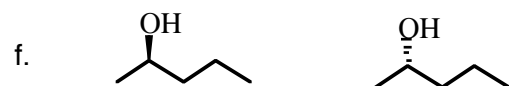
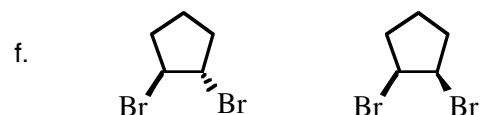
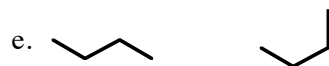
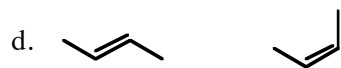




3. Classify the pairs of molecules as totally different, identical, structural isomers, diastereomers, or enantiomers. (2 points each)

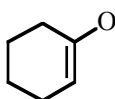


3. (continued) Classify the pairs of molecules as totally different, identical, structural isomers, diastereomers, or enantiomers. (2 points each)

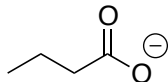
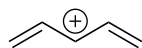


4. Draw at least four different isomers for  $C_5H_{10}$ . (There are lots more than four...) (6 points)

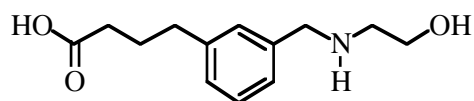
5. (a) Draw the appropriate number of lone pairs on the oxygen atom,  
 (b) Assign a formal charge on oxygen if appropriate,  
 (c) Draw an additional resonance structure for the following, and  
 (d) Identify which of the two structures would make the greater contribution to the hybrid. (4 points)



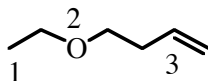
6. Draw resonance structures for each of the following:.



7. Identify the functional groups in the following molecule. (4 points)



8. Classify the hybridization and bond angles (109, 120, or 180) at the labelled atoms. (4 points)



C-1

O-2

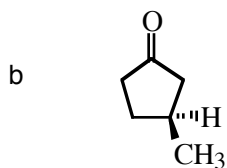
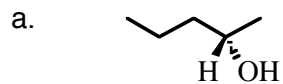
C-3

9. Draw both chair conformations of trans-1-methyl-3-isopropylcyclohexane, and circle the more stable one. (5 points.)

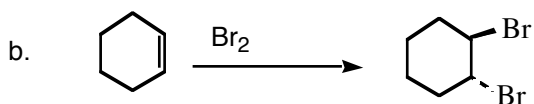
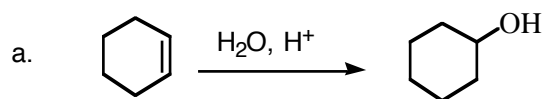
Note 1: It will simplify things if you abbreviate the isopropyl group as "R".

Note 2: Make sure that your second chair has the same "configuration" as the first, and is not an enantiomer.

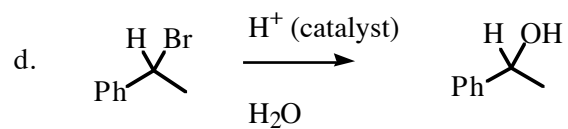
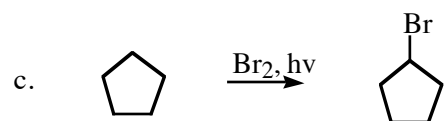
10. Classify each chiral carbon as R or S. (Some structures may have more than one chiral carbon!) (2 points each)



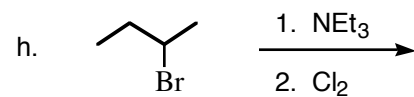
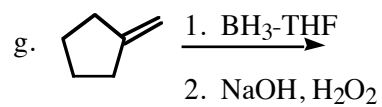
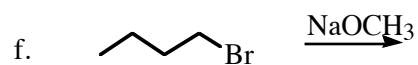
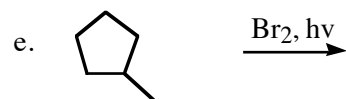
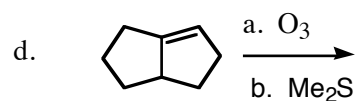
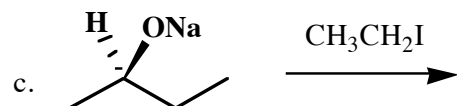
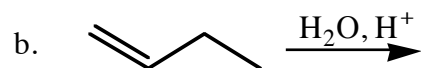
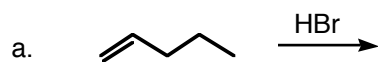
11. Mechanisms Problem. Draw the mechanism for the following reactions, and write "slow" next to the rate-determining step. Be sure to draw all intermediates, and to correctly draw "electron-movement" arrows or half-arrows. For radical reactions, draw propagation steps only. 4 points each.



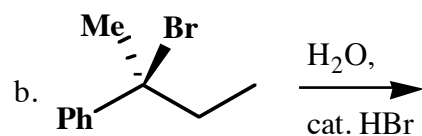
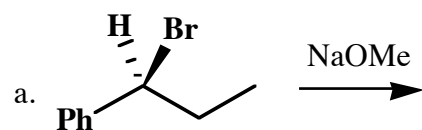
Mechs, continued



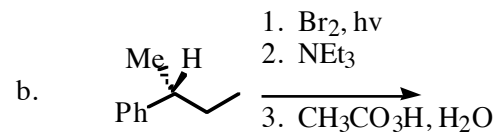
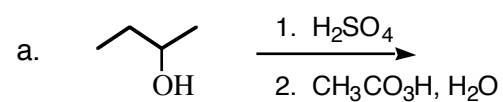
12. Predict the major products for the following reactions. In each case, pay careful attention to orientation and stereochemistry. Draw just one product in each case. (3 points each)



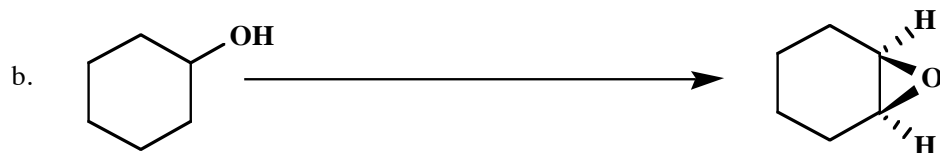
13. Draw the substitution products for the following reactions. (Do not draw any accompanying elimination products.) Include stereochemistry in your answer, and if two substitution products are formed, draw them both. Assume the starting material is optically active as drawn. (3 points each)



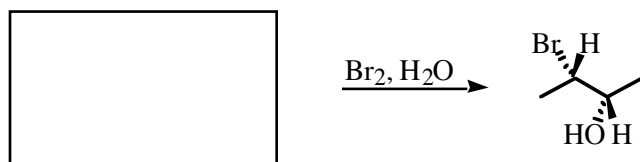
14. Draw the products of the following multi-step sequences. (4 points each)



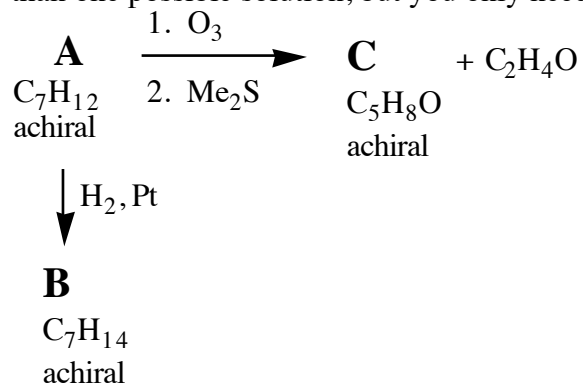
15. Provide reagents for the following transformations. More than one step is needed in each case. (4 points each)



16. Provide the appropriate reactant for the following transformation. (3 points)

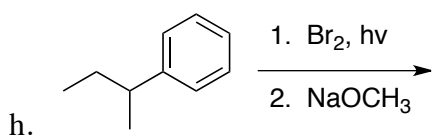
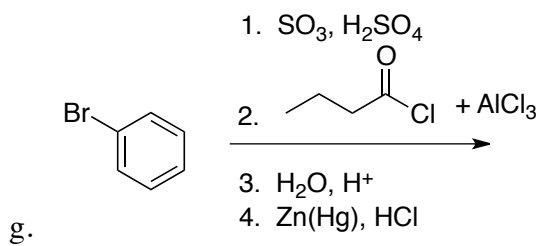
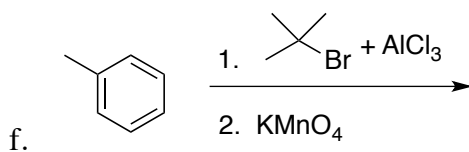
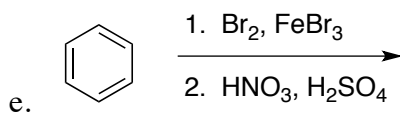
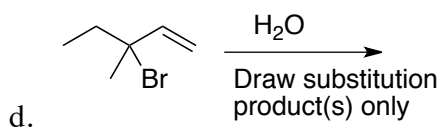
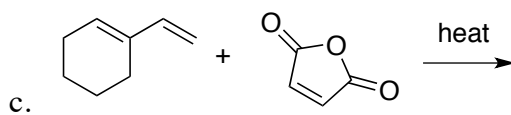
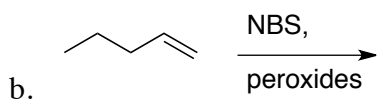
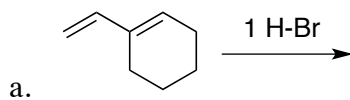


17. Suggest a structure for **A** that is consistent with the following information. (There is more than one possible solution, but you only need to provide one.) (5 points)

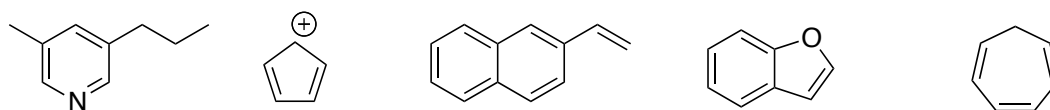




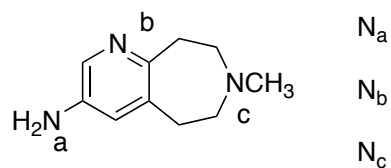
18. Draw the products for the following reactions:



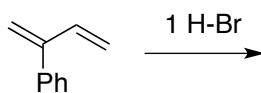
19. Which of the following are aromatic



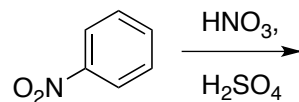
20. Classify the lone pair hybridization on the three nitrogen atoms in the following molecule:



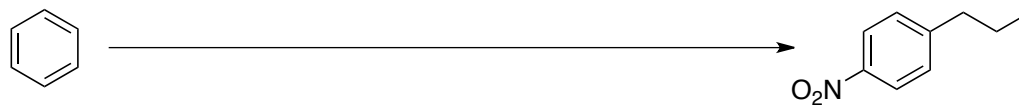
21. Draw the major products and mechanism for the following reaction:



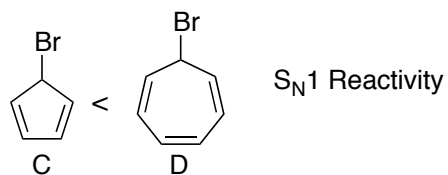
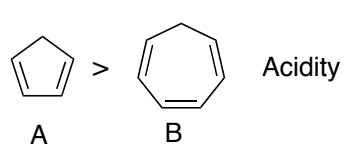
22. Draw the major product and mechanism for the following reaction. Draw all of the resonance structures for the key carbocationic intermediate



23. Design a synthesis for the following:



24. Explain why **A** is more acidic than **B**, but **C** is less reactive than **D** towards  $\text{S}_{\text{N}}1$  reactivity



25. Rank the following

