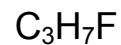
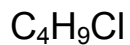
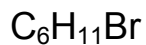
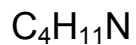
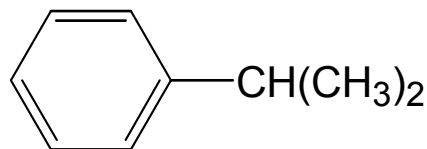
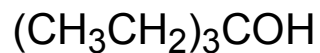
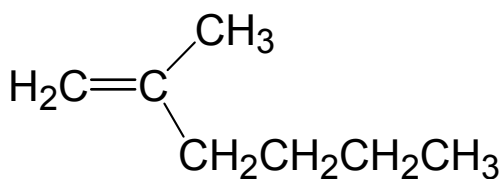
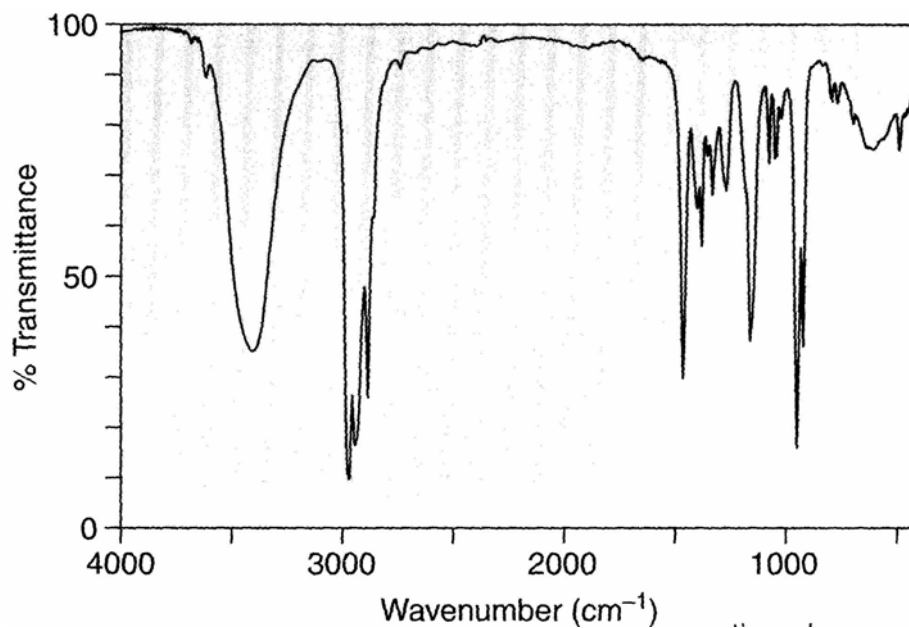


1. Multiple Choice Questions. Clearly circle your chosen answer. (30 points; 3 apiece)

a) Which compound gives M and M+2 peaks in the mass spectrum in a 3:1 ratio, respectively? (Problem 14.4, p 484)



b) Which compound gives the following IR spectrum? (Problem 14.32, p 501)



Name: _____ **KEY** _____

c) How many IR absorptions does an amino group, -NH_2 , give between 3000 cm^{-1} and 3500 cm^{-1} ?

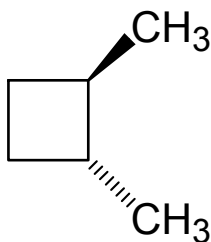
4

3

2

1

d) How many ^1H NMR signals does the following compound give? (Problem 15.33d, p 537)



5

4

3

2

e) Which statement is not true?

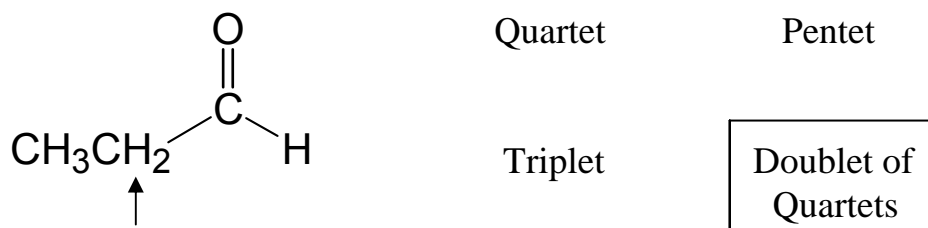
Addition of HBr to 1,3-butadiene gives a mixture of products.

The Diels-Alder reaction is stepwise.

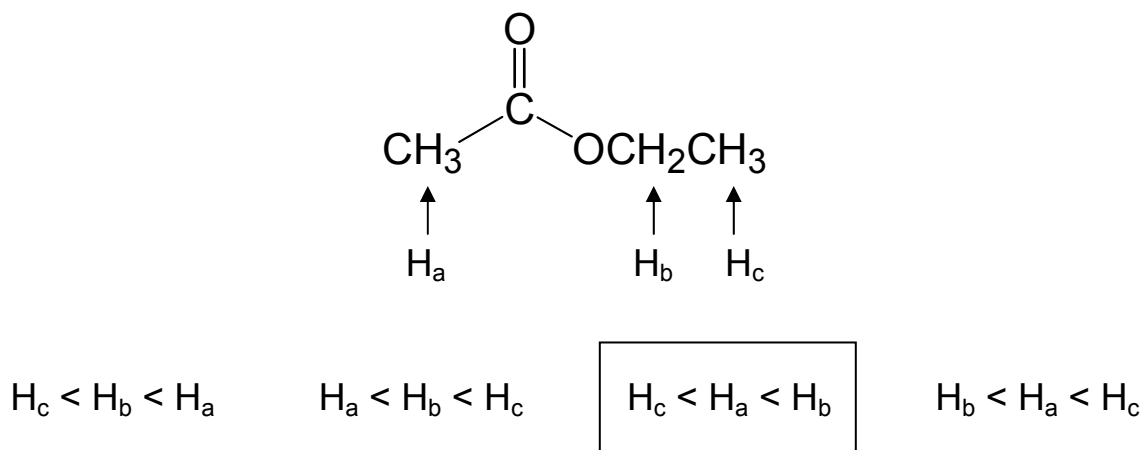
The Diels-Alder reaction is a thermal reaction.

E-1,3-pentadiene is more stable than 1,4-pentadiene.

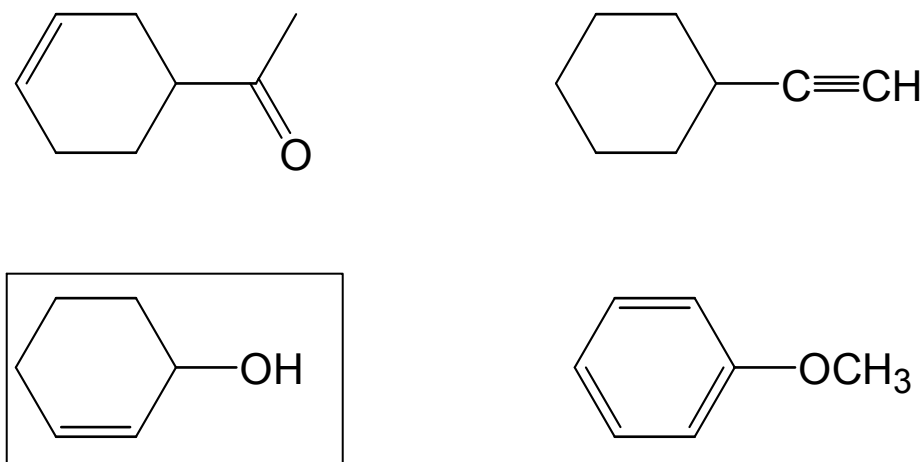
- f) Which statement characterizes the spin splitting of the indicated protons in the following compound? (Problem 15.40i, p 538)



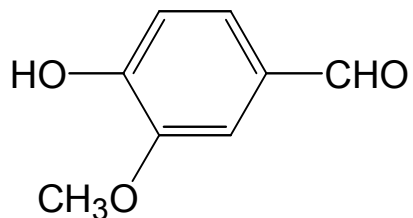
- g) Rank the indicated protons in the following molecule in order of increasingly downfield chemical shift? (Problem 15.11b, p 516)



- h) Which molecule gives IR absorptions at 3400 cm^{-1} (strong and broad) and at 1650 cm^{-1} ? (Problem 14.29, p 501)



c) How many ^1H NMR signals does vanillin give? (Problem 15.34, p 537)

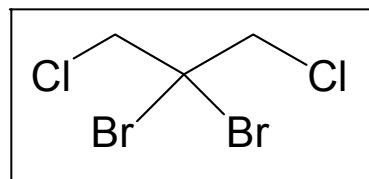
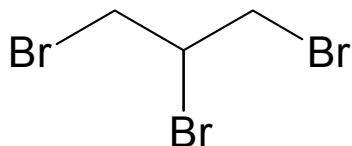


vanillin

4

6

d) Which compound gives one singlet in the ^1H NMR spectrum? (Problem 16.38, p 838)

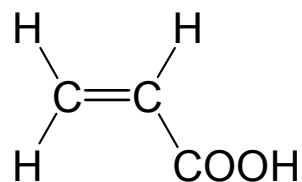
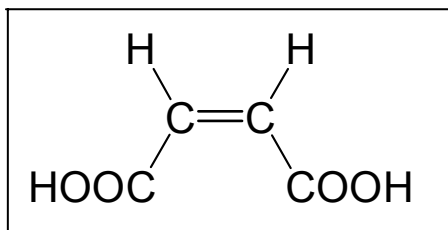


e) Which of the following has the higher energy per photon? (Problem 14.10b, p 489)

IR light of $\lambda = 10 \mu\text{m}$

IR light of $\lambda = 20 \mu\text{m}$

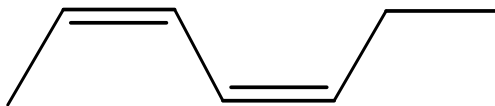
f) Which dienophile is more reactive in Diels-Alder reactions? (Problem 16.19, p 564)



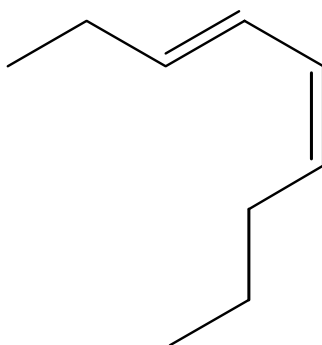
Name: _____ **KEY** _____

3. Draw structures of the following compounds. (8 points; 4 apiece)

a) The *Z,Z* stereoisomer of 2,4-heptadiene (Problem 16.35, p 574)

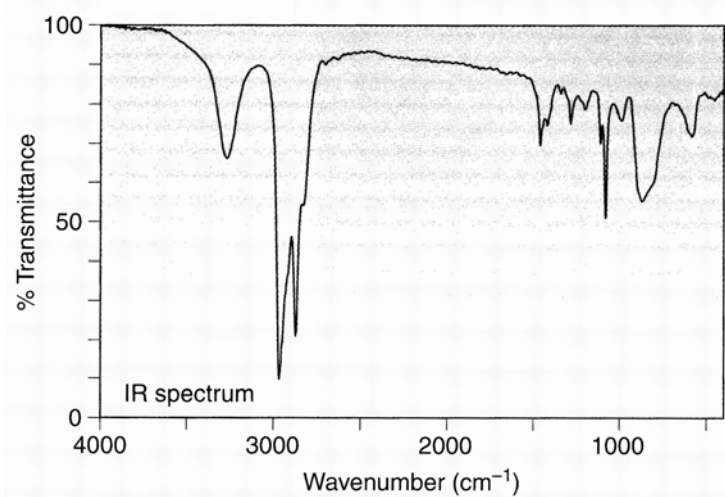
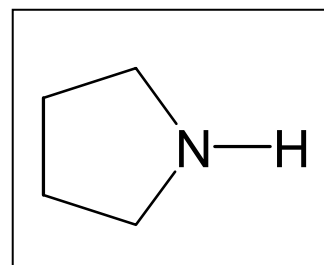
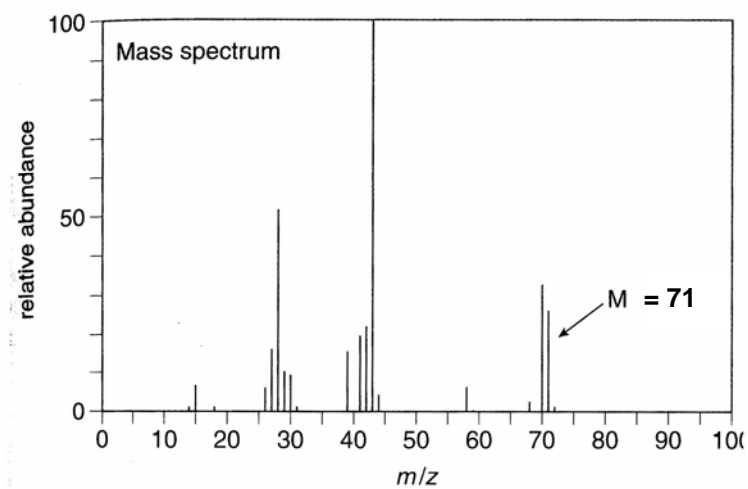


b) (*3E,5Z*)-3,5-nonadiene in the *s-cis* conformation (Problem 16.8b, p 553)



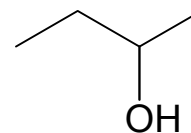
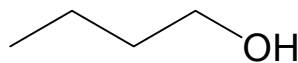
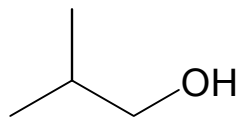
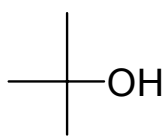
4. Structures from Spectroscopic Data (30 points; 5 apiece)

- a) What is the structure of a compound that gives the following IR and mass spectra?
(Problem 14.39, p 503)



- b) What is the structure of a compound that has a molecular ion at 74, an IR absorption at $3600\text{-}3200 \text{ cm}^{-1}$, and sp^3 hybridized CH absorption in the IR? There are no other major IR absorptions above 1500 cm^{-1} . (Problem 14.35c, p 502)

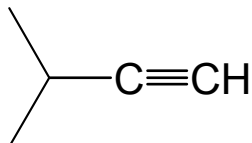
The formula gleaned from the mass spectrum, $\text{C}_4\text{H}_{10}\text{O}$, is consistent with any of the following:



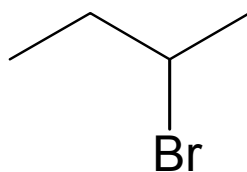
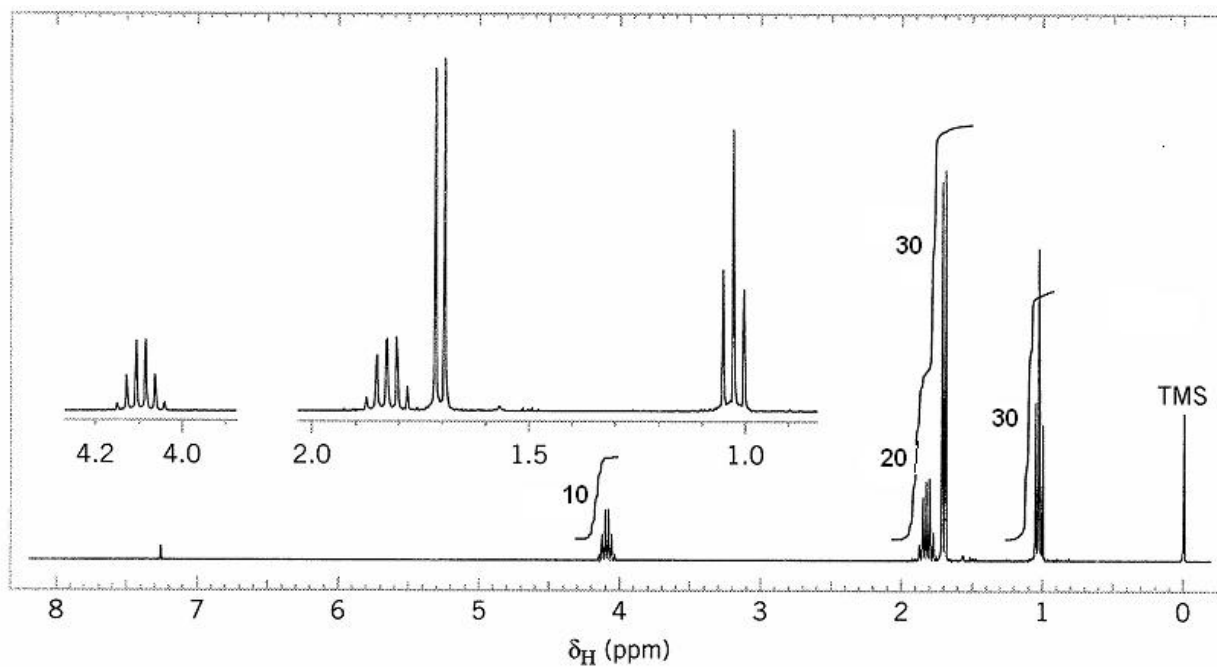
Name: _____ **KEY** _____

- c) A hydrocarbon has a molecular ion at $m/z = 68$ and IR absorptions at 3310, 3000-2850, and 2120 cm^{-1} . Provide a structure for this compound. (Problem 14.17a, p 499)

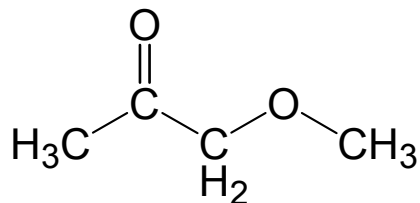
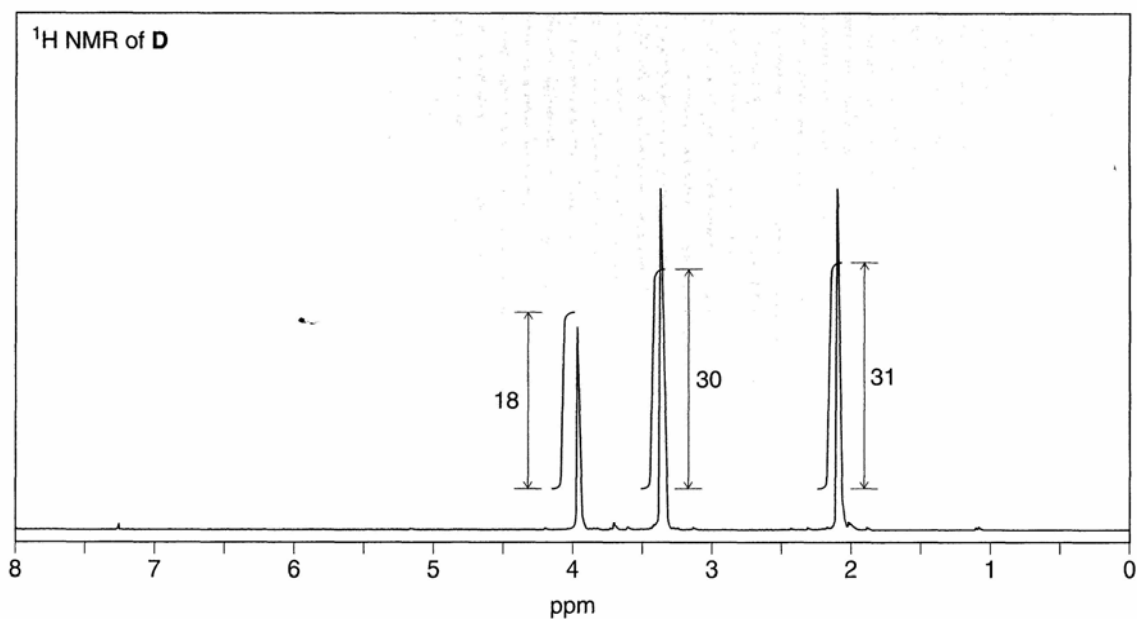
From $M = 68$, the formula is C_5H_8 . This and the IR data are consistent with either of the following molecules:



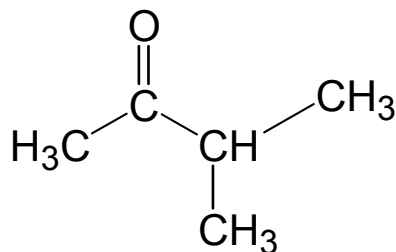
- d) A compound gives M and $M+2$ peaks in a 1:1 intensity ratio in the mass spectrum at $m/z = 136$ and $m/z = 138$. The ^1H NMR spectrum of the compound is below. What is the structure of the compound?



- e) A compound **D** (molecular formula $C_4H_8O_2$) gives a strong IR peak at 1730 cm^{-1} . The ^1H NMR spectrum is shown below. What is the structure of **D**? (Problem 15.44, p 539)

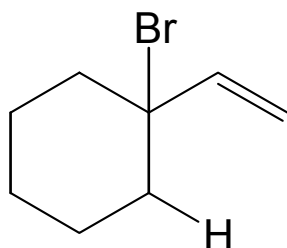
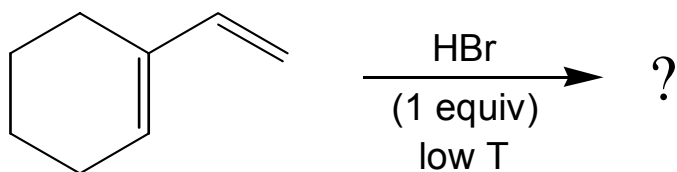


- f) A compound that has the formula $C_5H_{10}O$ has a strong IR absorption at 1720 cm^{-1} and the following ^1H NMR data: δ 1.10 (doublet, 6H), δ 2.10 (singlet, 3H), δ 2.50 (septet, 1H). What is the structure of the compound?

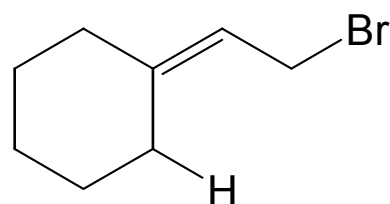


5. Provide the missing products or reactants for the following reactions. If more than one product is formed, indicate which is the major and which the minor product. If there is no reaction, so indicate. (12 points; 4 apiece)

a) Problem 16.38d, p 574

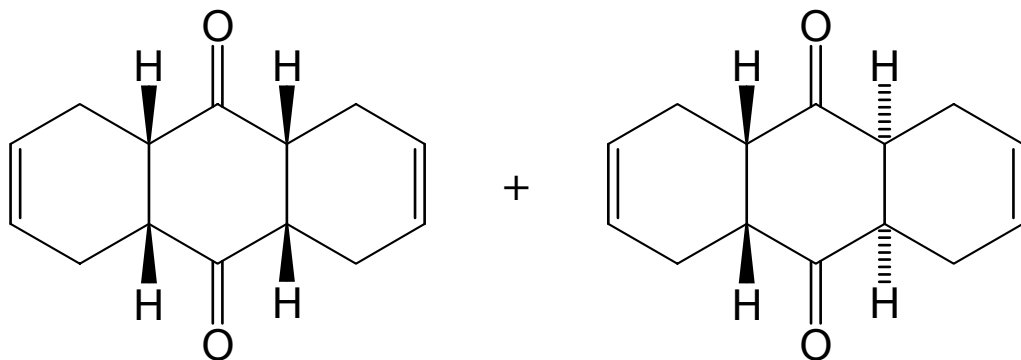
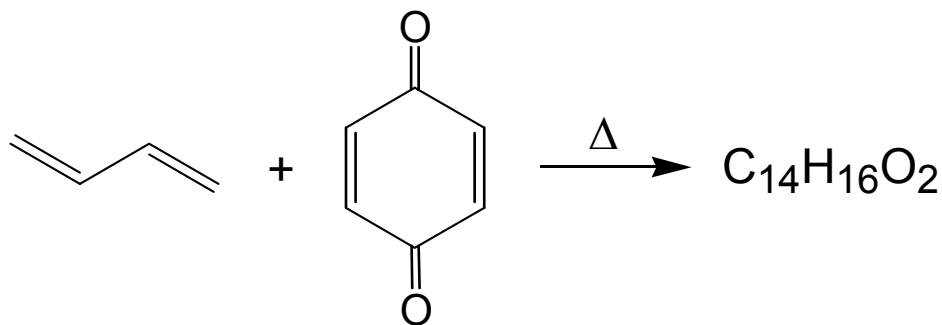


1,2-product (major)

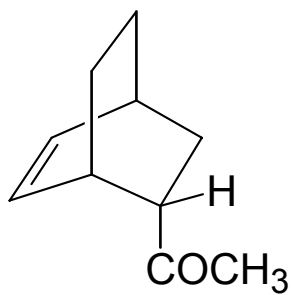
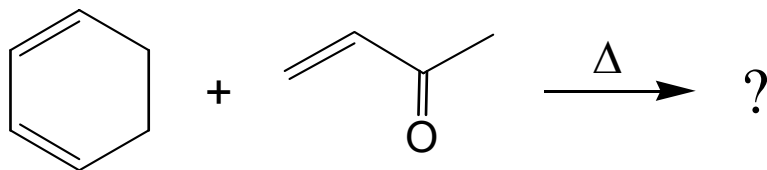


1,4-product (minor)

b) Problem 16.50, p 575

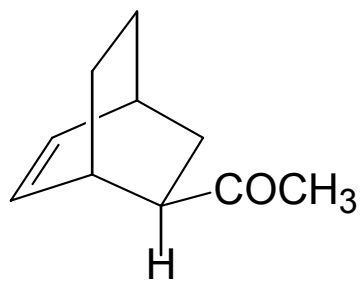


c) Problem 16.44f, p 575



endo product (major)

+ enantiomer



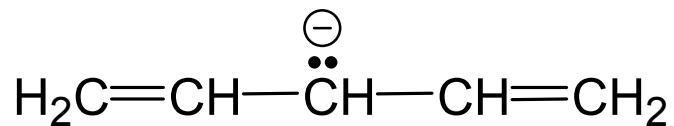
exo product (minor)

+ enantiomer

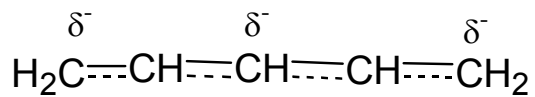
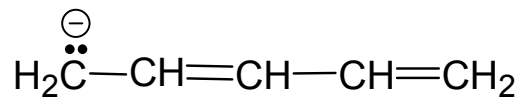
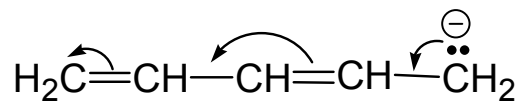
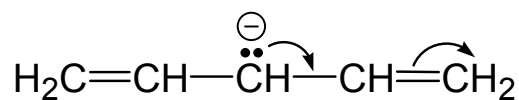
Both products are chiral!

Name: _____ **KEY** _____

6. By using electron pushing, show additional resonance structures for the following anion. Draw the structure of the resonance hybrid. (Problem 16.5a; 8 points)



Electron pushing:



Resonance Hybrid