

Seat No. \_\_\_\_\_

Last Name \_\_\_\_\_

First Name \_\_\_\_\_

**PLEASE REMOVE LAST PAGE OF EXAM BEFORE PRINTING YOUR NAME ON THE BACK OF PAGE 13. THERE ARE 14 PAGES TO THIS EXAM**

**FINAL EXAM**  
**CHEMISTRY 331**  
Spring 2007  
Monday, April 30  
7:30 to 9:30 a.m.

Course Grade

I. (24 pts) = \_\_\_\_\_

II. (72 pts)

24 pts

A-H

24 pts

I-P

24 pts

Q-X

= \_\_\_\_\_

III. (30 pts) = \_\_\_\_\_

IV. (15 pts) = \_\_\_\_\_

V. (16 pts) = \_\_\_\_\_

VI. ( 6 pts) = \_\_\_\_\_

VII. A-B (12 pts) = \_\_\_\_\_

C ( 6 pts) = \_\_\_\_\_

D ( 7 pts) = \_\_\_\_\_

VIII. (12 pts) = \_\_\_\_\_

A 6pts

B 6 pts

= \_\_\_\_\_

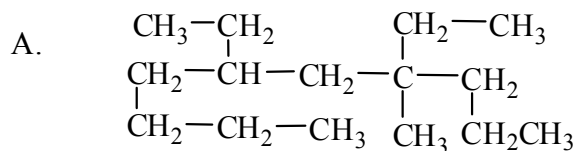
TOTAL FINAL EXAM (200 pts) = \_\_\_\_\_

**To be filled in by graders:**

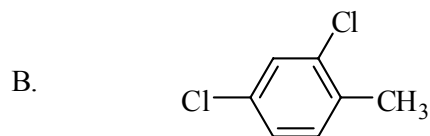
Number of quizzes taken (Cannot exceed 10) \_\_\_\_\_

**Exams will be held until October 1, 2007.**

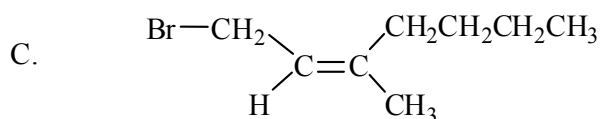
I. (24 pts) Provide a proper name for each of the following compounds. (Include R or S, cis or trans, or Z or E when required).



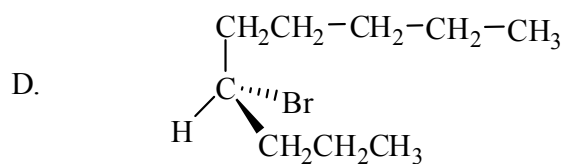

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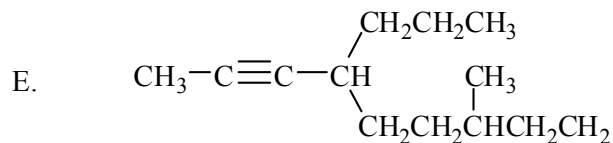

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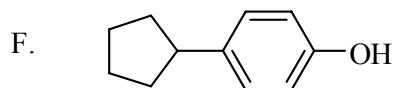

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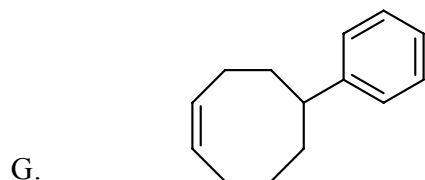

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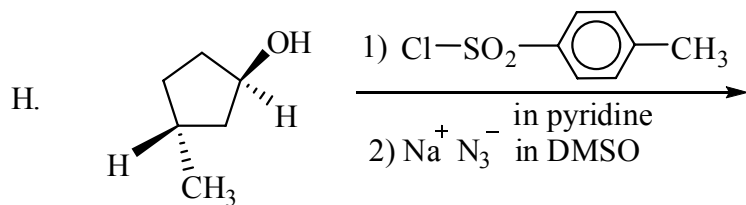
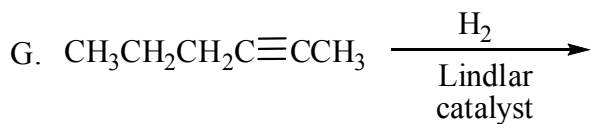
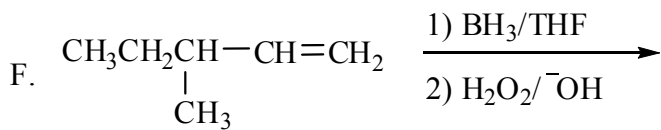
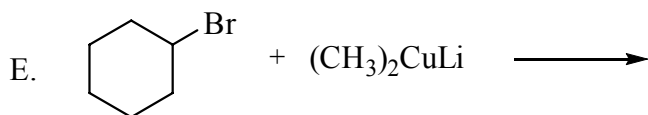
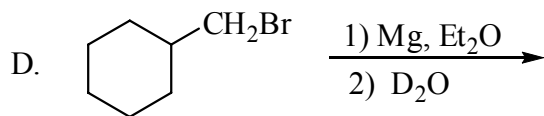
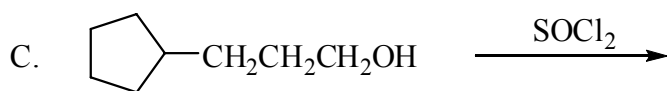
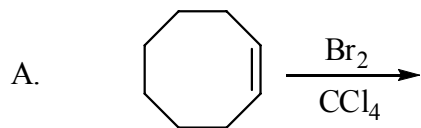

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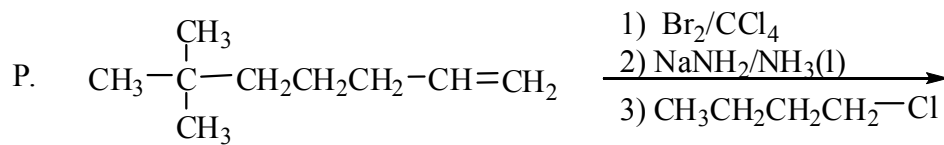
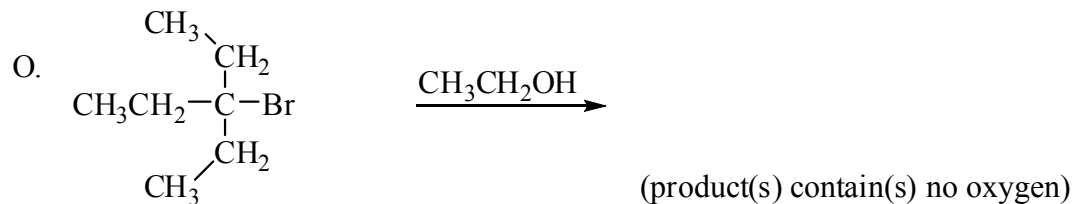
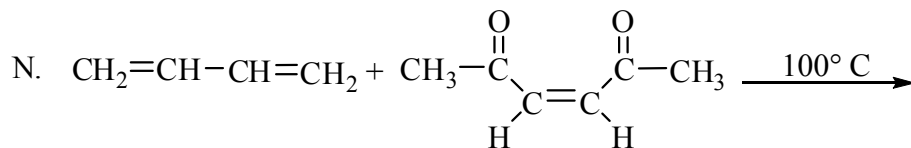
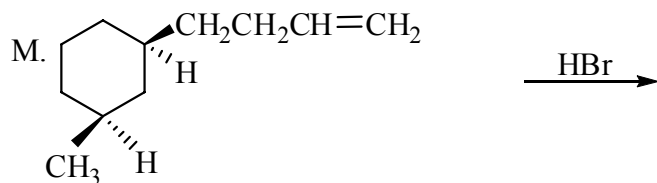
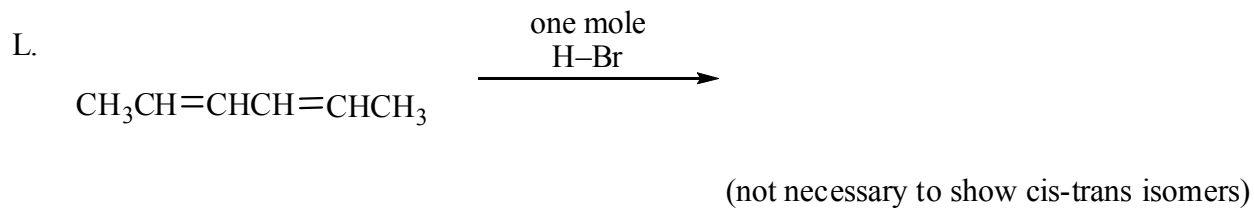
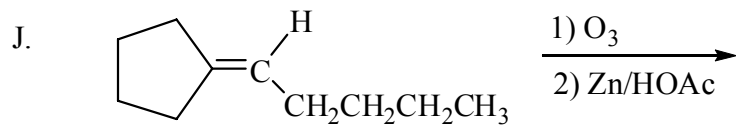
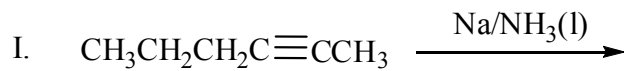


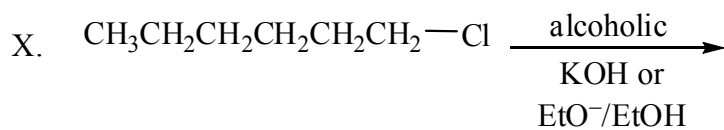
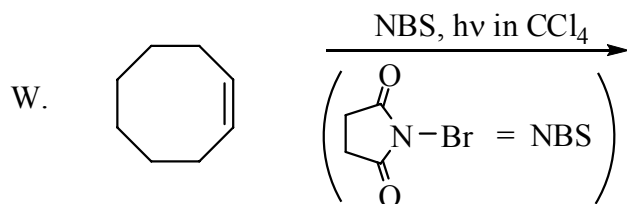
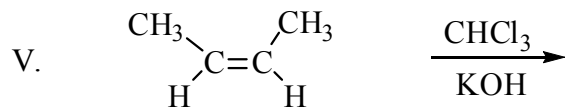
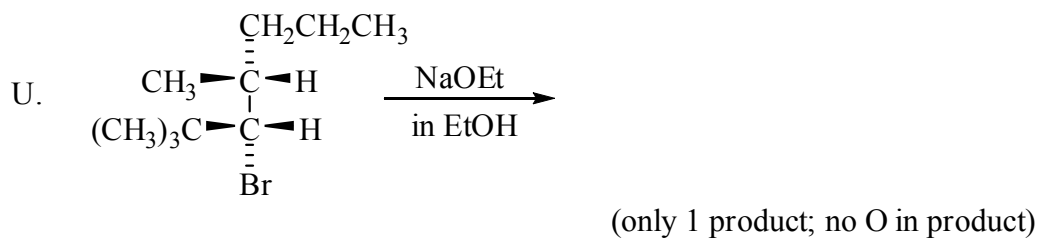
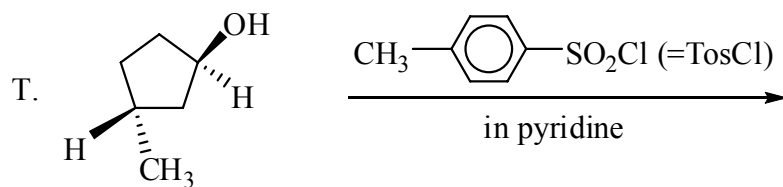
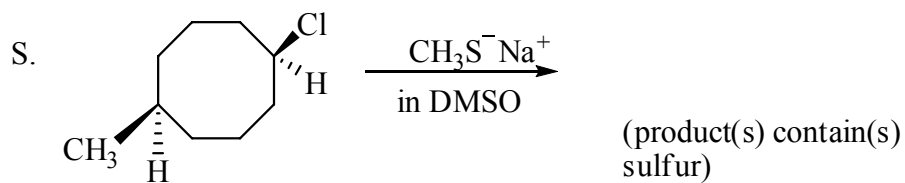
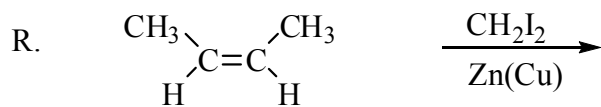
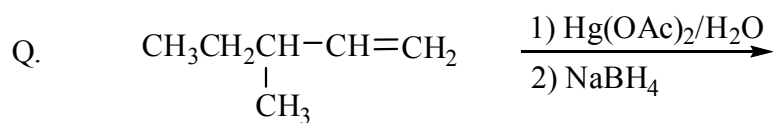

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H. Draw the more stable chair conformation of *cis*-1-ethyl-4-methylcyclohexane.

II. (72 pts) Complete the following equations giving all organic product(s) or reagents as required. Stereochemistry must be clearly indicated in reactions that are stereoselective.

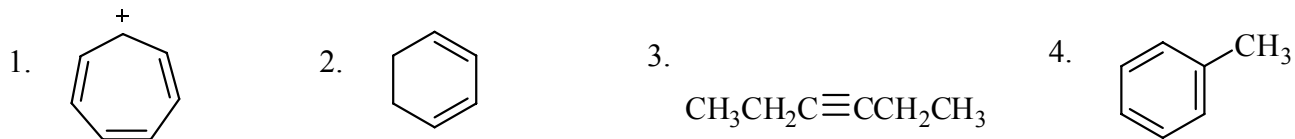




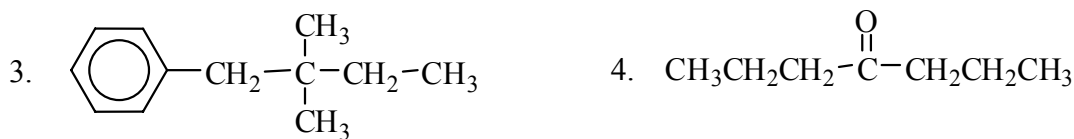
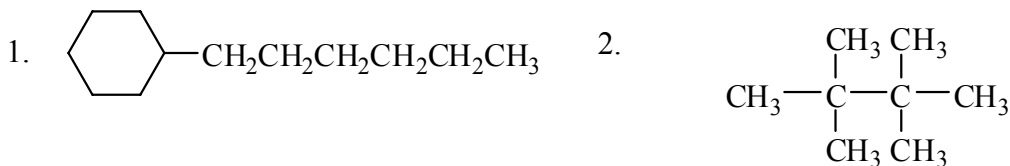


III. (30 pts) Circle the correct answer.

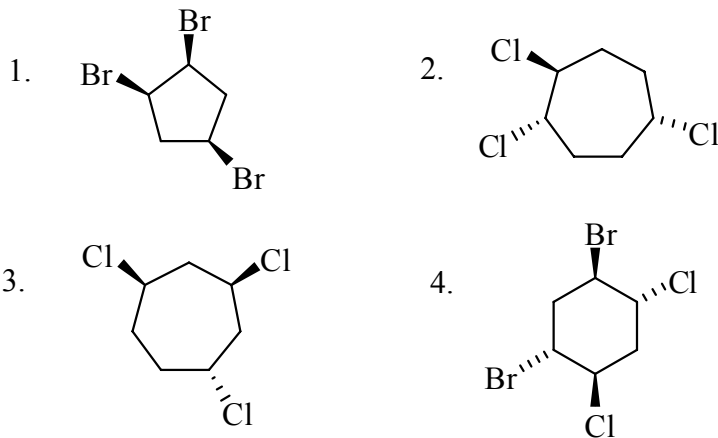
A. Which of the following molecules or ions has no atoms that can be described as  $sp^3$  hybridized?



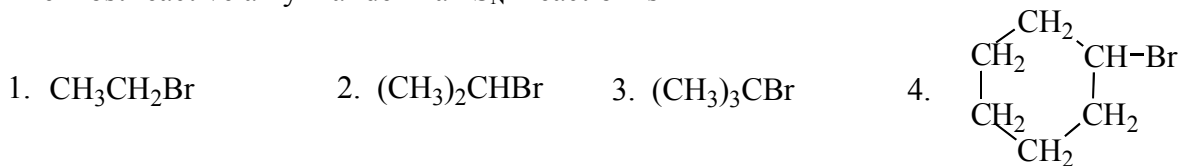
B. The compound which would be most likely to give a mass spectrum with a prominent peak at  $m/e$  57 = is



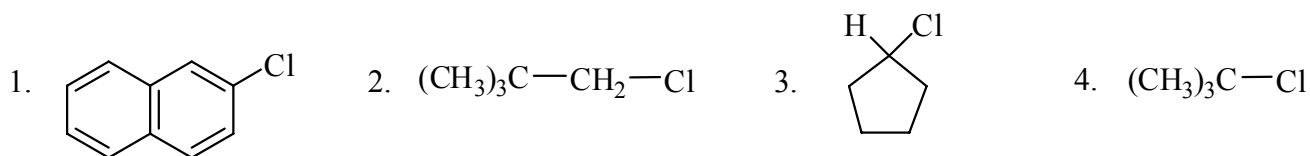
C. Which compound is a meso compound?



D. The most reactive alkyl halide in an  $S_N2$  reaction is



E. The reaction  $\text{R-Cl} + \text{Ag}^+ \rightarrow \text{R}^+ + \text{AgCl}$  will happen most rapidly if  $\text{R-Cl}$  is



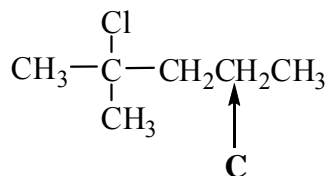
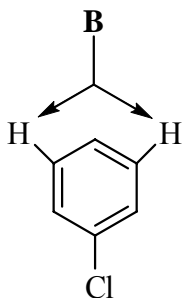
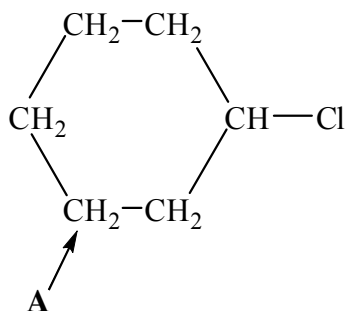
F. In the chemistry of vision, the absorption of light brings about

1. a substitution reaction.
2. an elimination reaction.
3. an isomerization reaction.
4. a free radical reaction.

G. The molecular formula of *para*-phenylaniline is

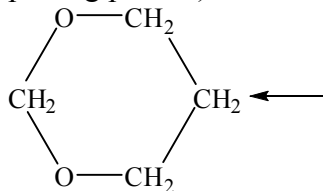
1.  $C_6H_7N$
2.  $C_{12}H_{11}N$
3.  $C_{13}H_{13}N$
4. None of the formulas given.

H. The indicated pairs of hydrogen atoms **A**, **B**, and **C** are:



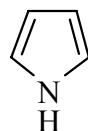
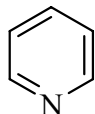
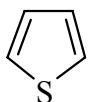
- |  |  |  |  |
|--|--|--|--|
| 1. <b>A</b> -diastereotopic<br><b>B</b> -enantiotopic<br><b>C</b> -homotopic | 2. <b>A</b> -enantiotopic<br><b>B</b> -homotopic<br><b>C</b> -diastereotopic | 3. <b>A</b> -diastereotopic<br><b>B</b> -homotopic<br><b>C</b> -enantiotopic | 4. <b>A</b> -homotopic<br><b>B</b> -diastereotopic<br><b>C</b> -enantiotopic |
|--|--|--|--|

I. What multiplicity (splitting pattern) is observed in the  $^1H$  NMR spectrum for the indicated hydrogen?



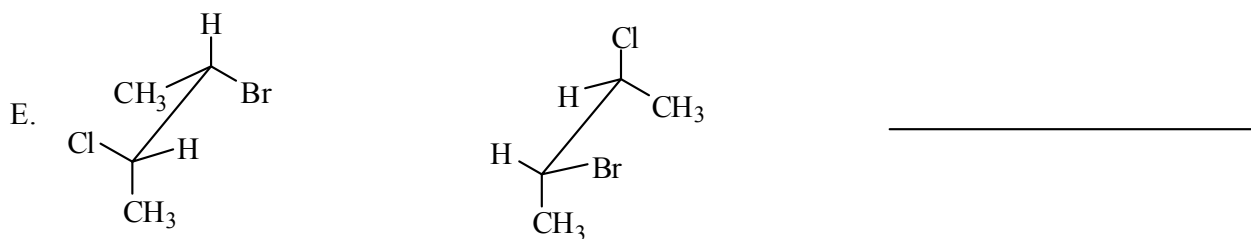
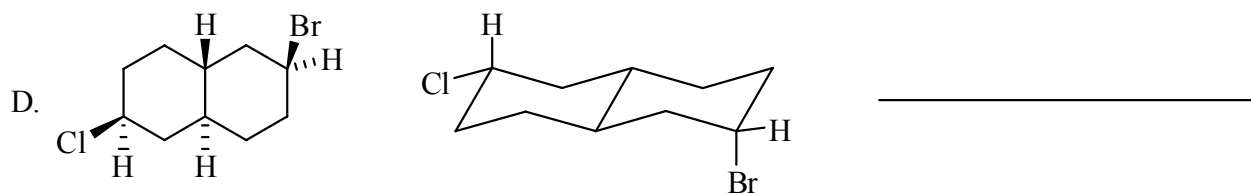
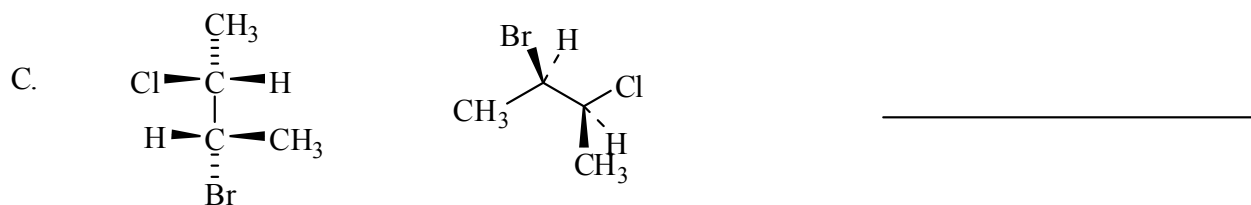
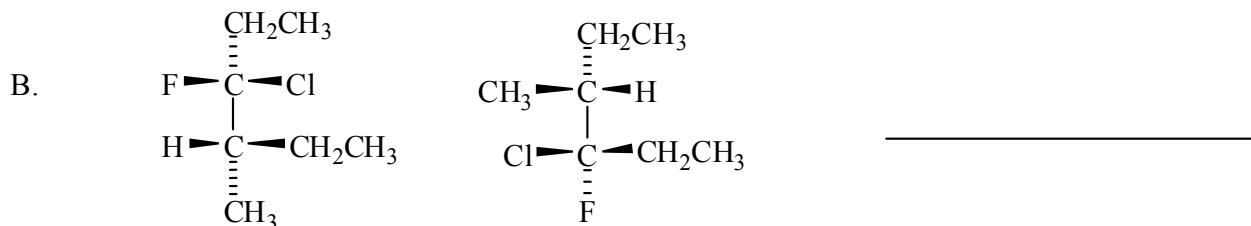
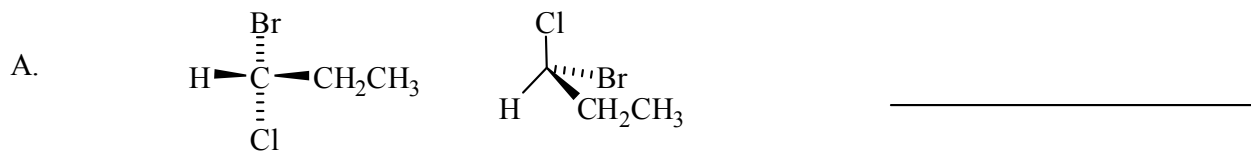
1. doublet
2. triplet
3. quartet
4. quintet

J. The names for the following three compounds are in which list?

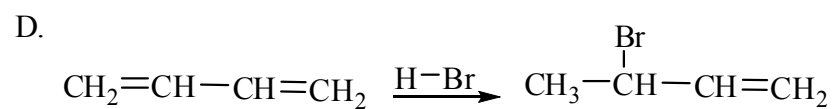
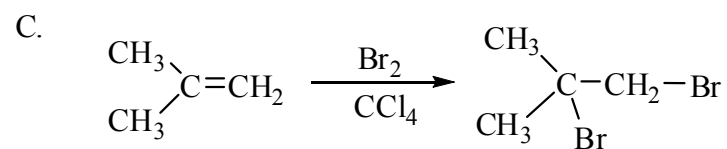
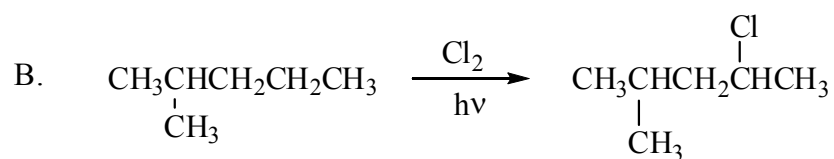
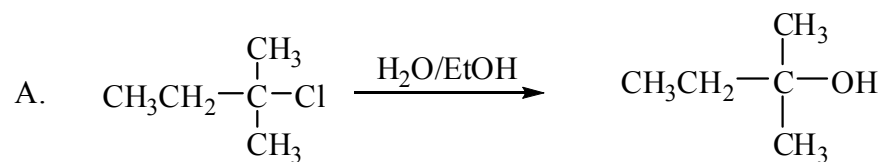


- |                                    |                                 |                                     |                                |
|------------------------------------|---------------------------------|-------------------------------------|--------------------------------|
| 1. furan<br>naphthalene<br>pyrrole | 2. furan<br>pyridine<br>pyrrole | 3. pyrrole<br>pyridine<br>thiophene | 4. pyran<br>pyrrole<br>styrene |
|------------------------------------|---------------------------------|-------------------------------------|--------------------------------|

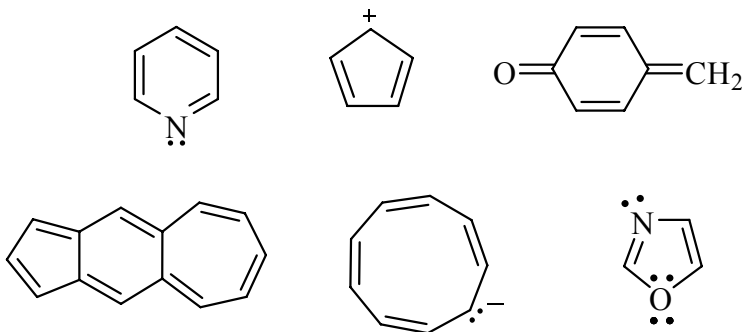
IV. (15 pts) For each of the following pair of compounds, label them as enantiomers, diastereomers, or identical. These are not frozen structures. Rotation around any single bond is possible.



V. (16 pts) Give only the **organic reactive intermediate** for the following reactions. If the intermediate is a resonance hybrid, give all major contributing structures. Do not give the entire mechanism. Place your answer in the appropriate box.



VI. (6 pts) Circle all of the species shown that would be expected to be aromatic.



VII. (25 pts) For each of the following compounds, propose a structure in the box provided that fits the data presented.

A. (6 pts)  $C_6H_{12}O_3$

$^1H$  NMR:

$\delta$  4.8 (1H, triplet)

$\delta$  3.4 (6H, singlet)

$\delta$  2.7 (2H, doublet)

$\delta$  2.2 (3H, singlet)

Broadband decoupled  $^{13}C$  NMR:

$\delta$  205.2

$\delta$  101.5

$\delta$  53.8

$\delta$  47.3

$\delta$  31.0

IR:

$1710\text{ cm}^{-1}$

$1100\text{ cm}^{-1}$



B. (6 pts)  $C_{11}H_{16}O$

$^1H$  NMR:

$\delta$  7.2 (2H, doublet)

$\delta$  6.8 (2H, doublet)

$\delta$  5.4 (1H, singlet)

$\delta$  1.6 (2H, quartet)

$\delta$  1.2 (6H, singlet)

$\delta$  0.7 (3H, triplet)

Broadband decoupled  $^{13}C$  NMR:

$\delta$  152.8       $\delta$  37.3

$\delta$  141.8       $\delta$  37.0

$\delta$  127.1       $\delta$  28.6

$\delta$  114.8       $\delta$  9.1

IR:

$3500\text{ cm}^{-1}$

$1100\text{ cm}^{-1}$



C. (6 pts)  $C_8H_{11}N$

$^1H$  NMR

$\delta$  6.8 (2H, singlet)

$\delta$  2.5 (6H, singlet)

$\delta$  2.2 (3H, singlet)

Broadband decoupled  $^{13}C$  NMR

$\delta$  157.3

$\delta$  147.3

$\delta$  121.1

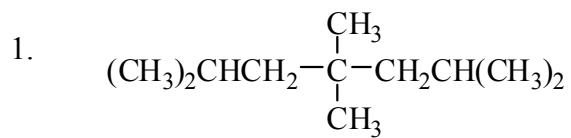
$\delta$  24.3

$\delta$  20.8

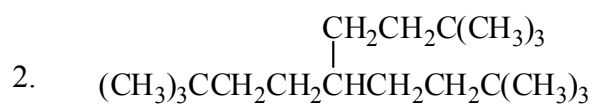


(At least two structures fit the data, only one needs to be given.)

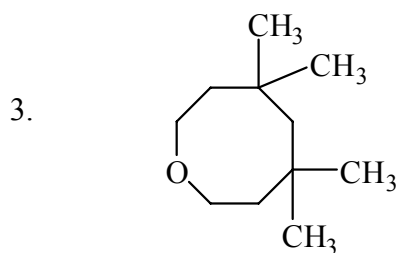
D. (7 pts) How many  $^{13}\text{C}$  signals would each of the following compounds show? Put your answer in the blank provided.



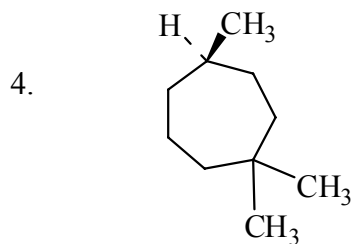
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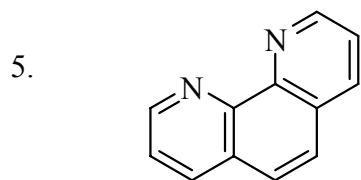
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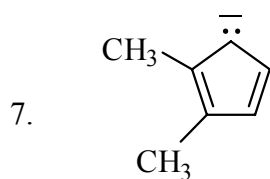
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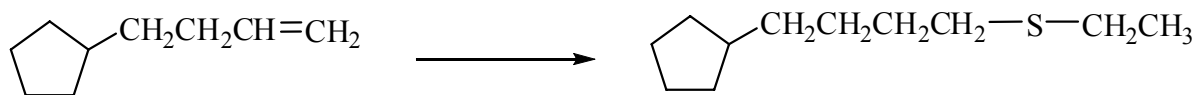
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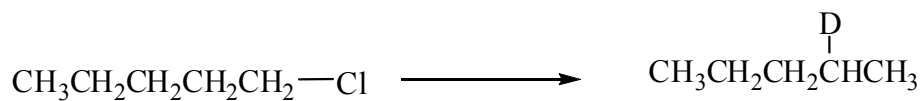
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VIII. (12 pts) Beginning with the starting material indicated, show how to achieve each of the following syntheses by showing all the reactions that are needed (for each reaction, give the starting material, conditions over the arrow, and the products). You may use any inorganic compound or organic compound with one or two carbon atoms.

A. (6 pts)



B. (6 pts)



**CHARACTERISTIC PROTON CHEMICAL SHIFTS**

Type of proton	Chemical shift $\delta$ , ppm	
Cyclopropane	0.2	
Primary	$\begin{array}{c} \text{H} \\   \\ \text{RC}-\text{H} \end{array}$	0.9
	$\begin{array}{c} \text{H} \\   \\ \text{H} \\   \\ \text{R}_2\text{C}-\text{H} \end{array}$	1.3
Tertiary	$\text{R}_3\text{C}-\text{H}$	1.5
Vinyllic	$\text{C}=\text{C}-\text{H}$	4.6-5.9
Acetylenic	$\text{C}\equiv\text{C}-\text{H}$	2-3
Aromatic	$\text{Ar}-\text{H}$	6-8.5
Benzylic	$\text{Ar}-\text{C}-\text{H}$	2.2-3
Allylic	$\text{C}=\text{C}-\text{C}-\text{H}$	1.7
Fluorides	$\text{H}-\text{C}-\text{F}$	4.4-5
Chlorides	$\text{H}-\text{C}-\text{Cl}$	3-4
Bromides	$\text{H}-\text{C}-\text{Br}$	2.5-4
Iodides	$\text{H}-\text{C}-\text{I}$	2-4
Alcohols	$\text{H}-\text{C}-\text{OH}$	3.4-4
Ethers	$\text{H}-\text{C}-\text{OR}$	3.3-4
Esters	$\text{RCOO}-\text{C}-\text{H}$	3.7-4.1
Esters	$\text{H}-\text{C}-\text{COOR}$	2-2.2
Acids	$\text{H}-\text{C}-\text{COOH}$	2-2.6
Carbonyl compounds	$\text{H}-\text{C}-\text{C}=\text{O}$	2-2.7
Aldehydic	$\begin{array}{c} \text{H} \\   \\ \text{RC}=\text{O} \end{array}$	9-10
	$\text{RO}-\text{H}$	1-5.5
Phenolic	$\text{ArO}-\text{H}$	4-12
Enolic	$\text{C}=\text{C}-\text{O}-\text{H}$	15-17
Carboxylic	$\text{RCOO}-\text{H}$	10.5-12
Amino	$\begin{array}{c} \text{H} \\   \\ \text{RN}-\text{H} \end{array}$	1-5
	DEPT 90	CH
DEPT 135	CH, CH <sub>3</sub> positive signal	

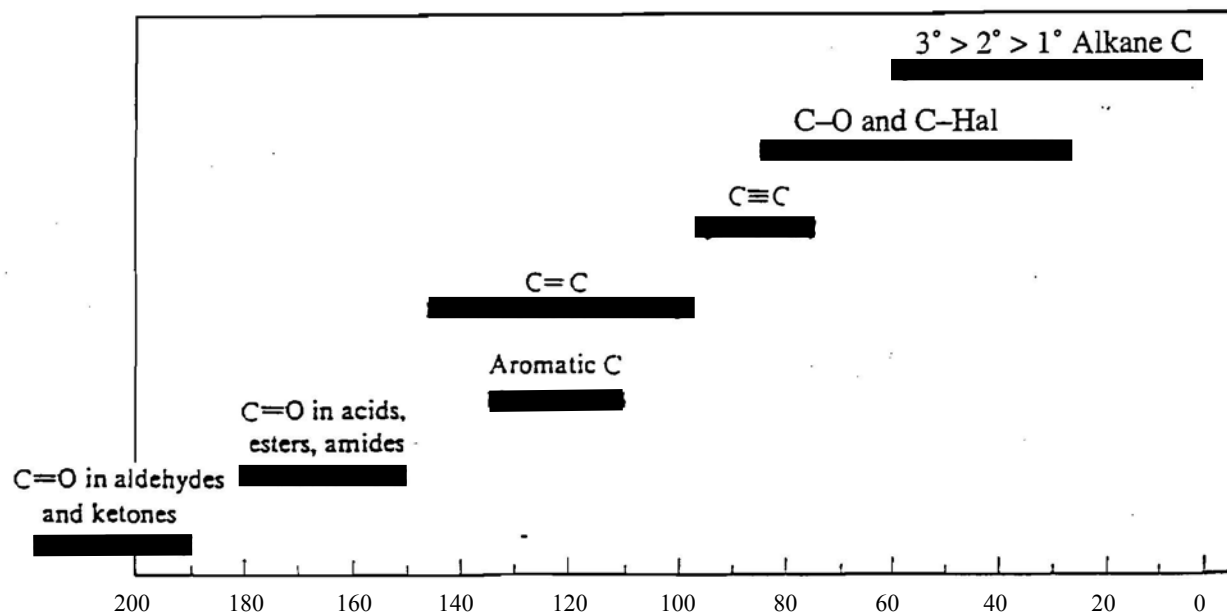
**CHARACTERISTIC INFRARED ABSORPTION FREQUENCIES**

Bond	Compound type	Frequency range, cm <sup>-1</sup>
C—H	Alkanes	2850-2960
C—H	Alkenes	1350-1470
C—H	Aromatic rings	3020-3080 ( <i>m</i> ) 675-1000
C—H	Alkynes	3000-3100 ( <i>m</i> ) 675-870
C=C	Alkenes	3300
C≡C	Alkynes	1640-1680 ( <i>v</i> )
C=C	Aromatic rings	2100-2260 ( <i>v</i> )
C—O	Alcohols, ethers, carboxylic acids, esters	1500, 1600 ( <i>v</i> )
C=O	Aldehydes, ketones, carboxylic acids, esters	1080-1300
O—H	Monomeric alcohols, phenols	1690-1760
	Hydrogen-bonded alcohols, phenols	3610-3640 ( <i>v</i> )
	Carboxylic acids	3200-3600 ( <i>broad</i> )
N—H	Amines	2500-3000 ( <i>broad</i> )
C—N	Amines	3300-3500 ( <i>m</i> )
C≡N	Nitriles	1180-1360
—NO <sub>2</sub>	Nitro compounds	2210-2260 ( <i>v</i> ) 1515-1560 1345-1385

\*All bands strong unless marked: *m*, moderate; *v*, variable.

**Abbreviated Periodic Table**

1A		8B										8A					
1	2A	3A	4A	5A	6A	7A	8	9	10	11	12	13	14	15	16	17	18
1 H 1.01	2											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.2
3 Li 6.94	4 Be 9.01											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
11 Na 23.0	12 Mg 24.3	3B 3	4B 4	5B 5	6B 6	7B 7	8	9	10	11 11	12 12	13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9
19 K 39.1	20 Ca 40.1	21 Sc 45.0	22 Ti 47.9	23 V 50.9	24 Cr 52.0	25 Mn 54.9	26 Fe 55.8	27 Co 58.9	28 Ni 58.7	29 Cu 63.5	30 Zn 65.4	31 Ga 69.7	32 Ge 72.6	33 As 74.9	34 Se 79.0	35 Br 79.9	36 Kr 83.8

Chemical shifts for <sup>13</sup>C in various kinds of compounds.