

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

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

First Name \_\_\_\_\_  
(Please print your name)

Lecture Section.   A  

*Circle your recitation number and time:*

- |                  |                   |                    |
|------------------|-------------------|--------------------|
| 1) Fri. 12:10 PM | 6) Mon. 4:10 PM   | 11) Fri. 11:00 AM  |
| 2) Fri. 2:10 PM  | 7) Tues. 9:00 AM  | 12) Mon. 11:00 AM  |
| 3) Fri. 3:10 PM, | 8) Tues. 12:10 PM | 13) Mon. 2:10 PM   |
| 4) Mon. 12:10 PM | 9) Tues. 1:10 PM  | 14) Tues. 10:00 AM |
| 5) Mon. 1:10 PM  | 10) Fri. 9:00 AM  |                    |

**There are 10 pages to this exam. Check to make sure you have a complete exam.**

## CHEMISTRY 331

### EXAM IV

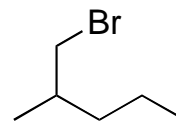
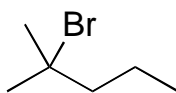
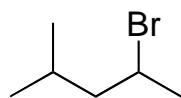
Tuesday, November 6, 2007

- |                    |       |
|--------------------|-------|
| I. (15 points)     | _____ |
| II. (21 points)    | _____ |
| III. (15 points)   | _____ |
| IV. ( 9 points)    | _____ |
| V. ( 9 points)     | _____ |
| VI. ( 8 points)    | _____ |
| VII. ( 9 points)   | _____ |
| VIII. (14 points)  | _____ |
| <hr/>              |       |
| TOTAL (100 points) | _____ |

**All spectra were obtained from the NIST webbook (<http://webbook.nist.gov/chemistry/>).**

**Ia. Rank the alkyl halides (1, 2, 3 where 1 is fastest) in each group in order of increasing SN1 reactivity. (6 pts)**

a)

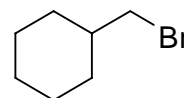
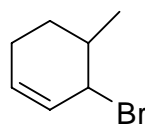
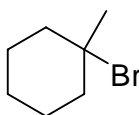


\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

b)



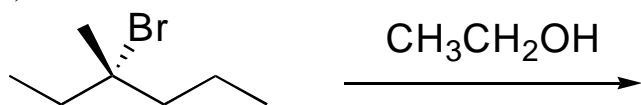
\_\_\_\_\_

\_\_\_\_\_

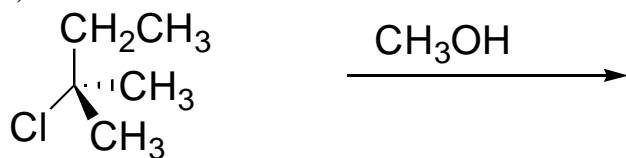
\_\_\_\_\_

**Ib. Draw the product(s) of each substitution reaction and indicate the stereochemistry when necessary. (9 pts)**

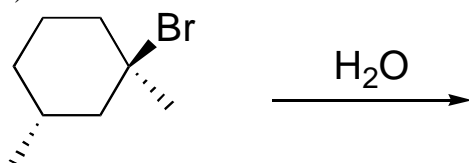
a)



b)

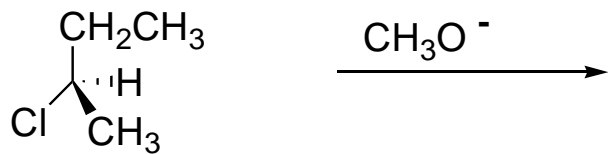


c)

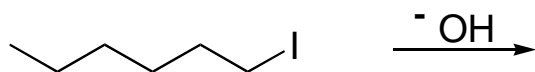


**IIa. Draw the product(s) of each SN2 reaction and indicate the stereochemistry when necessary. (12 pts)**

a)



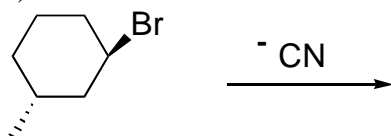
b)



c)

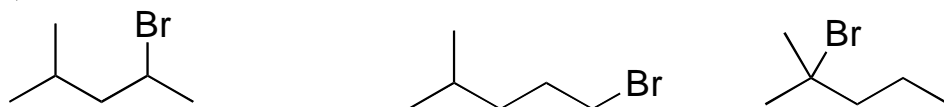


d)

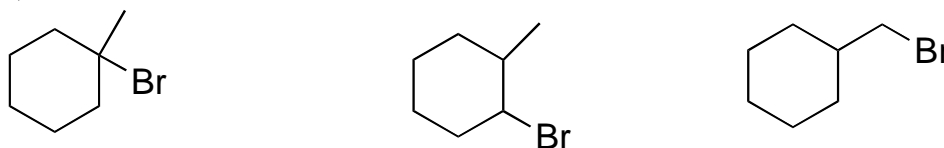


**IIb. Rank the alkyl halides (1,2,3 where 1 is the fastest) in each group in order of increasing SN2 reactivity. (9pts)**

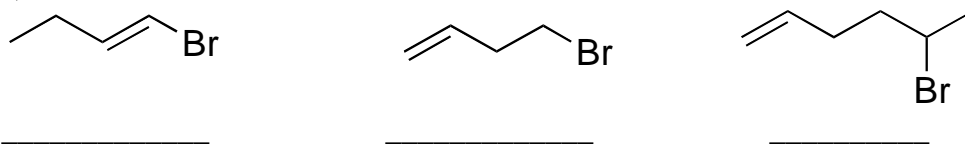
a)



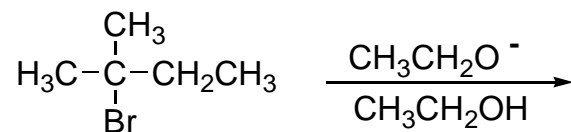
b)



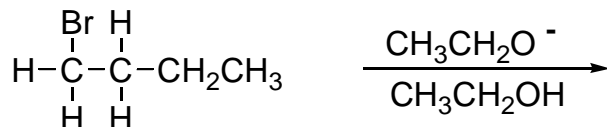
c)



IIIa. For the elimination reaction shown below, indicate the product(s) that are formed in addition to ethanol. If more than one product (in addition to ethanol) is formed, circle the one that will be the major product. (6pts)



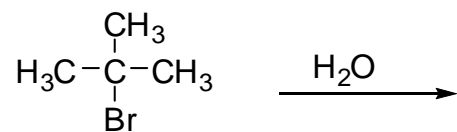
b) Give the product(s) and show the mechanism for the elimination reaction shown below. (6pts)



c) Complete the rate equation for the reaction shown in IIIb (3pts).

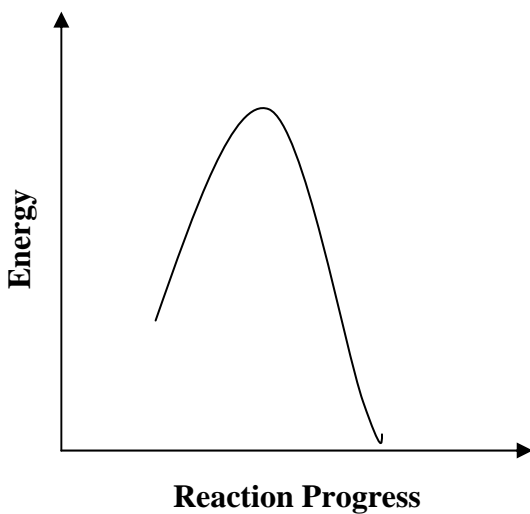
Rate of disappearance of RBr =

IVa. Give the product(s) and show the mechanism for the elimination reaction shown below. (5pts)

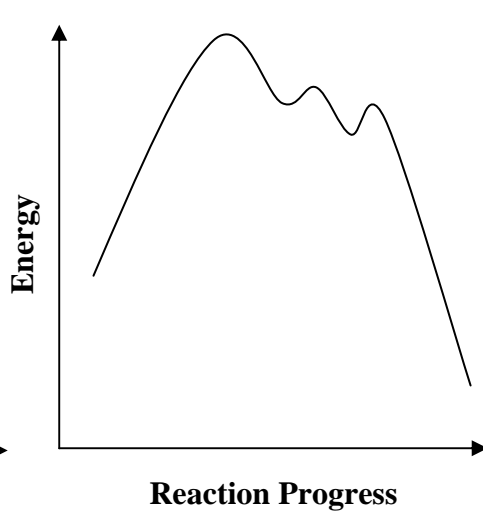


b) Which is the appropriate reaction energy diagram for the above reaction. (2pts). \_\_\_\_\_

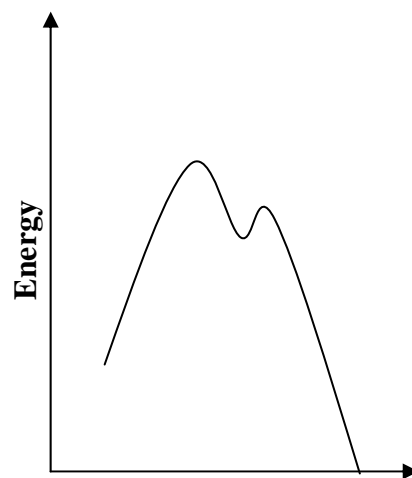
c) Which is the appropriate reaction energy diagram for reaction IIIb. (2pts). \_\_\_\_\_



A



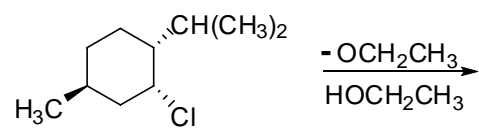
B



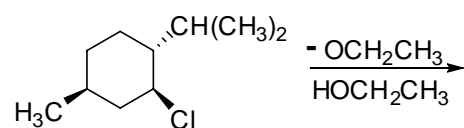
C

V. Draw the product(s) of each elimination reaction (not including ethanol) and indicate the stereochemistry when necessary. (9 pts)

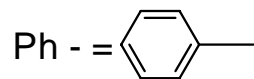
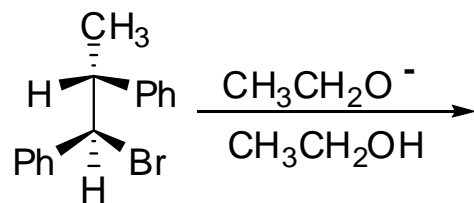
a)



b)

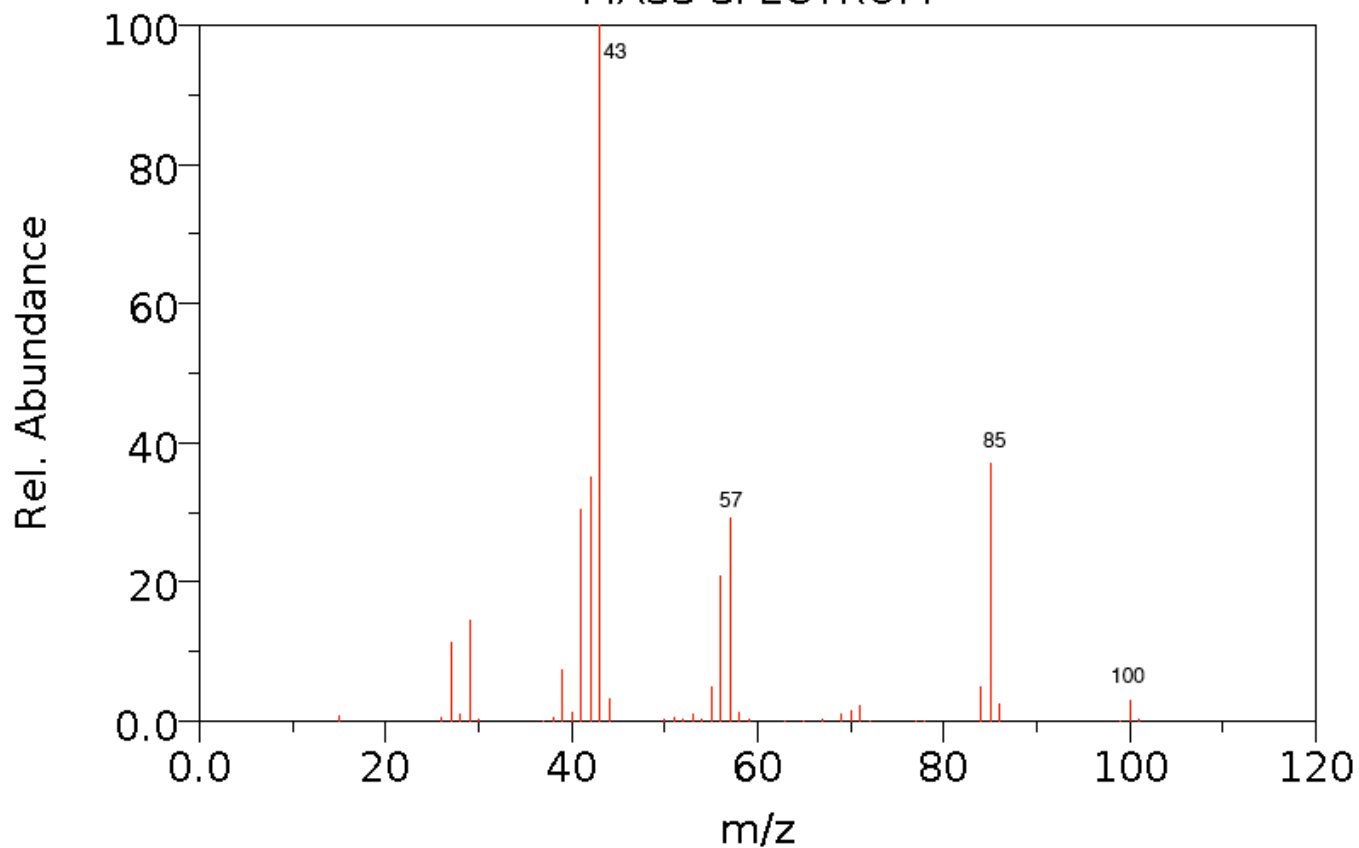


c)



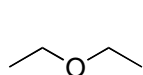
VI. The following questions refer to the spectrum of a hydrocarbon shown below (8pts).

### MASS SPECTRUM

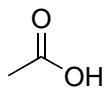


- What peak represents  $M^+$  (the parent peak or the molecular ion)?
- What peak represents the base peak?
- Propose structures for fragment ions at  $m/z=57$  and  $43$ .

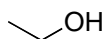
**VII. Indicate in the boxes which of the compounds below match with the appropriate IR spectra. (9pts)**



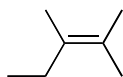
**A**



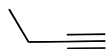
**B**



**C**



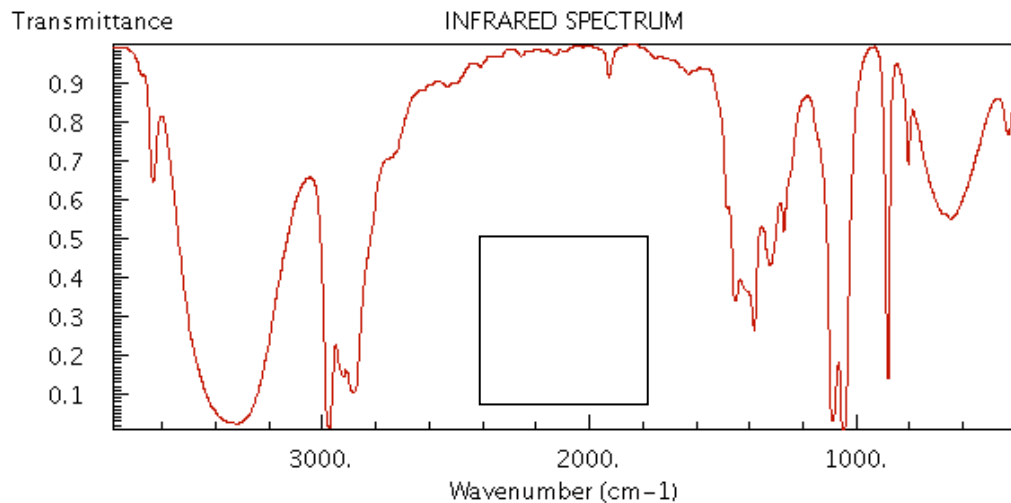
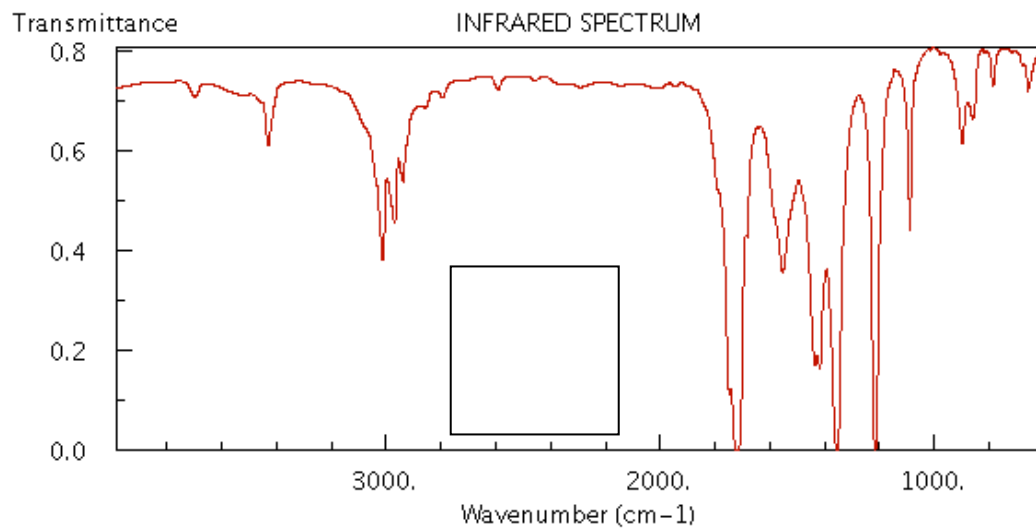
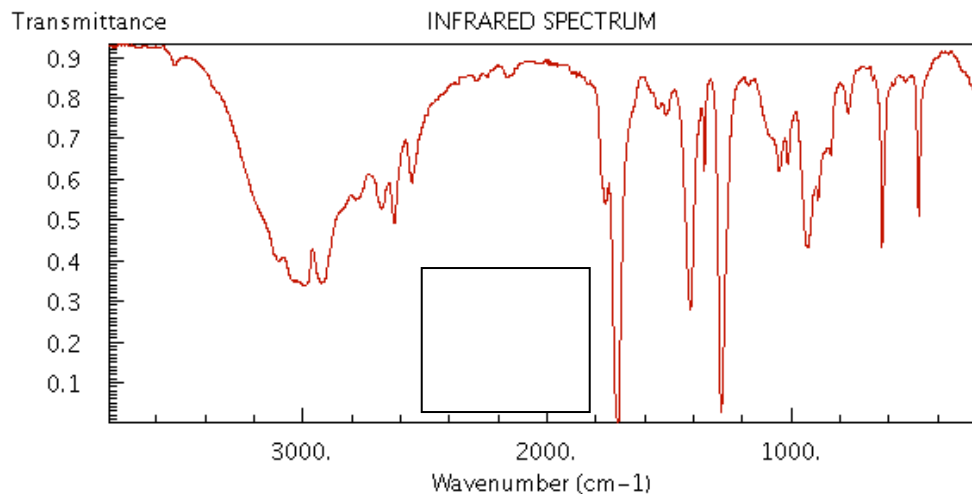
**D**



**E**

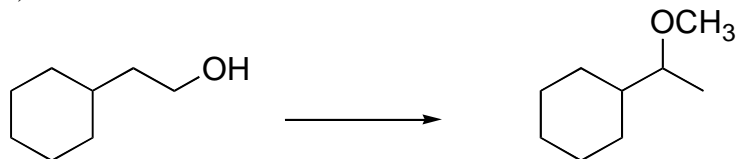


**F**

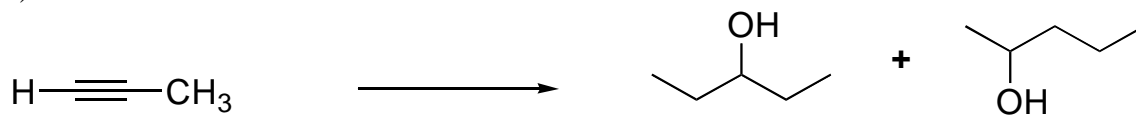


VIII. Beginning with the starting material indicated, show how to achieve the following two syntheses by showing all the reactions that are needed. (For each reaction, give the starting material, conditions over the arrow, and the products). You may use any inorganic compound or organic compound with one or two carbons. (14 pts.)

a)



b)



### CHARACTERISTIC INFRARED ABSORPTION FREQUENCIES

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

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

**Abbreviated Periodic Table**

1A 1	2A 2	8B										3A 13	4A 14	5A 15	6A 16	7A 17	8A 18												
1 H 1.01	2 He 4.00											3 Li 6.94	4 Be 9.01											5 B 10.8	6 C 12.0	7 N 14.0	8 O 16.0	9 F 19.0	10 Ne 20.2
11 Na 23.0	12 Mg 24.3	3B 3	4B 4	5B 5	6B 6	7B 7	8 8	9 9	10 10	11B 11	12B 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 78.0	35 Br 79.9	36 Kr 83.8												