

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

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

Lecture Section \_\_\_\_\_ A \_\_\_\_\_

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**

Fall 2007

Tuesday, December 11

7:00 to 9:00 p.m.

Course Grade

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

II. (72 pts)

24 pts

24 pts

24 pts

A-H

I-P

Q-X

= \_\_\_\_\_

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

IV. (20 pts) = \_\_\_\_\_

V. ( 9 pts) = \_\_\_\_\_

VI. ( 7 pts) = \_\_\_\_\_

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

VIII. (18 pts) = \_\_\_\_\_

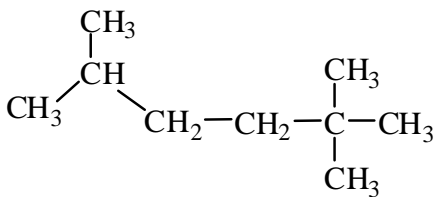
IX. ( 7 pts) = \_\_\_\_\_

X. (13 pts) = \_\_\_\_\_

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

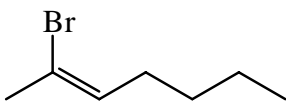
**Exams will be held until May 1, 2008.**

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).



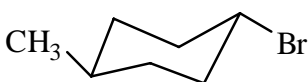
A.

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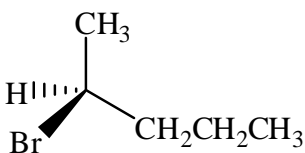
B.

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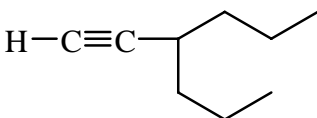
C.

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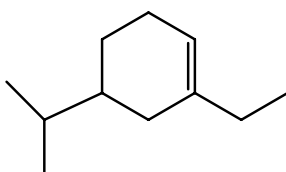
D.

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E.

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F.

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Write structural formulas for the following:

G. 4-vinylcyclopentene

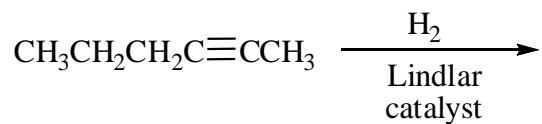
H. 2,6-dichlorophenol

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.

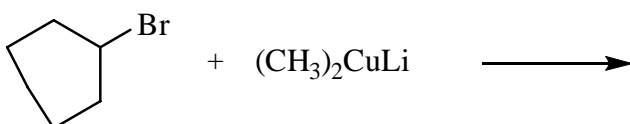
A.



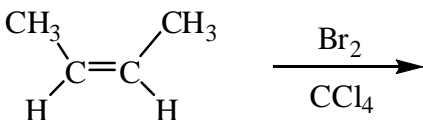
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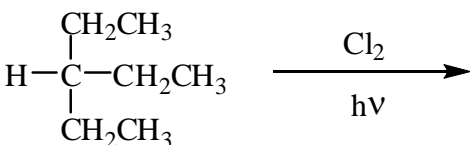
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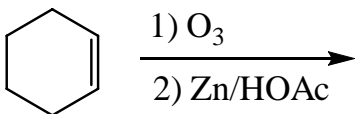
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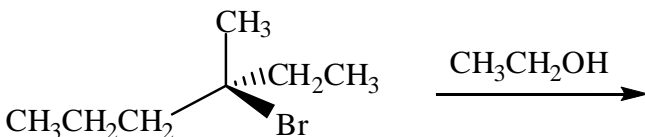
E.



F.

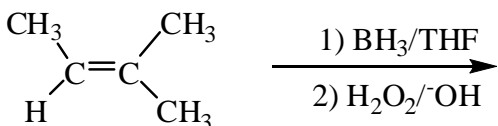


G.

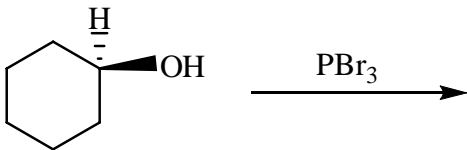


(product(s) contain(s) oxygen)

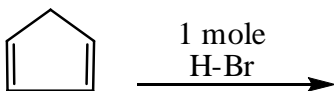
H.



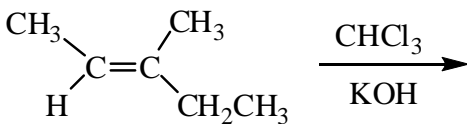
I.



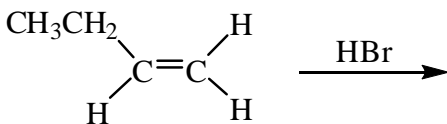
J.



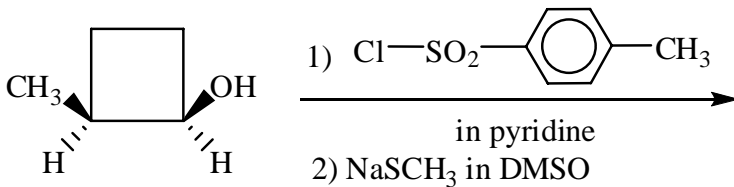
K.



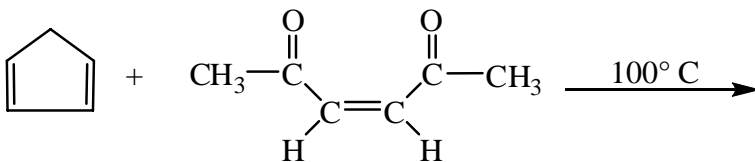
L.



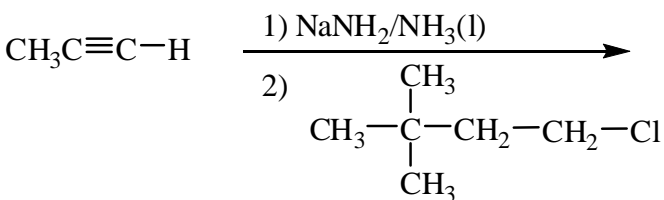
M.



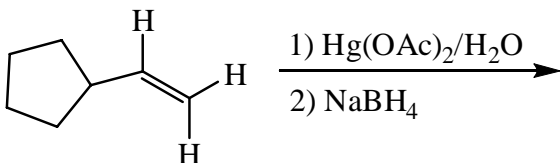
N.



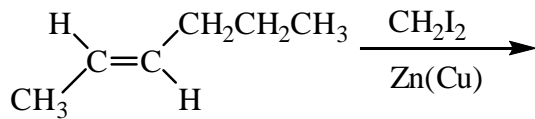
O.



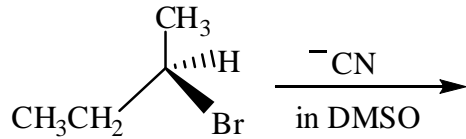
P.



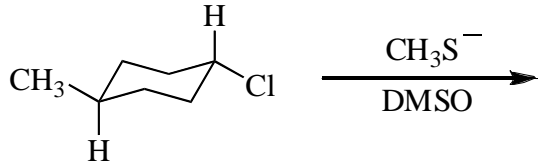
Q.



R.



S.

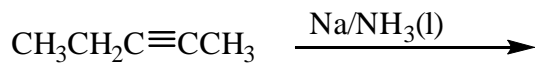


T.

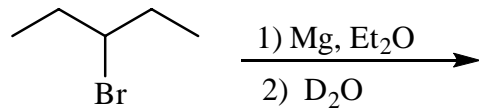


(not necessary to show cis-trans isomers)

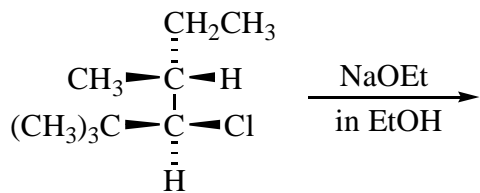
U.



V.

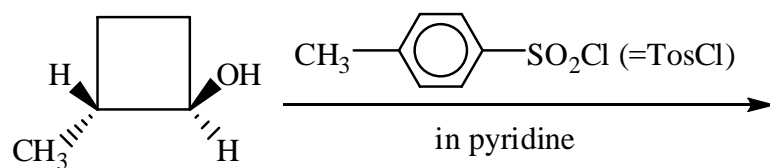


W.

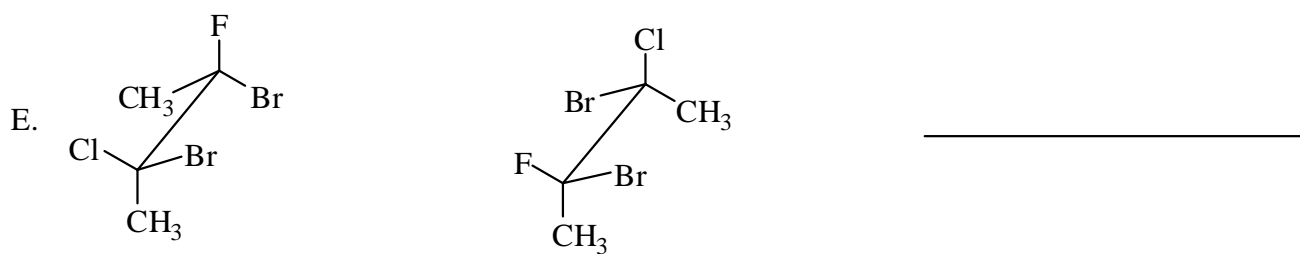
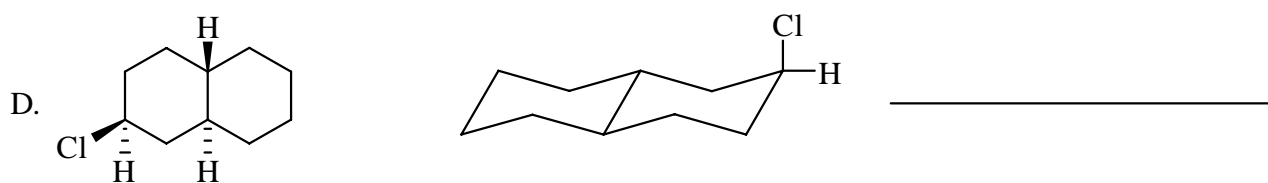
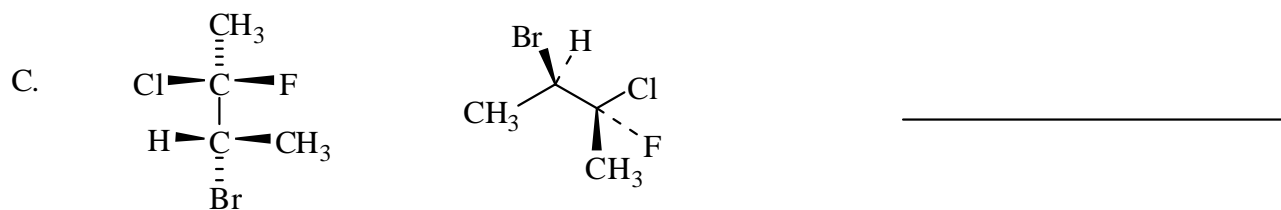
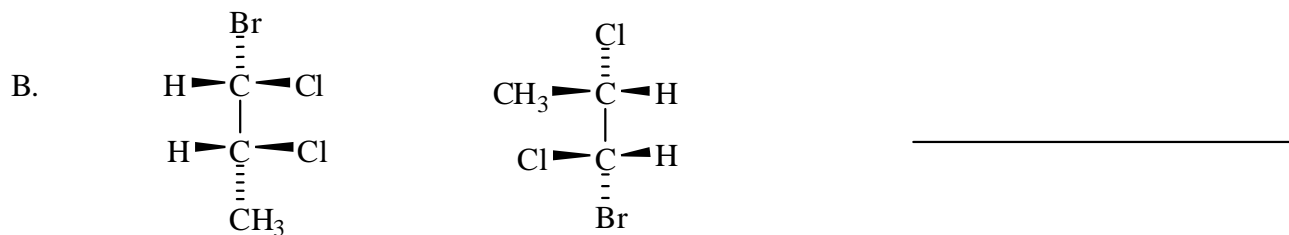
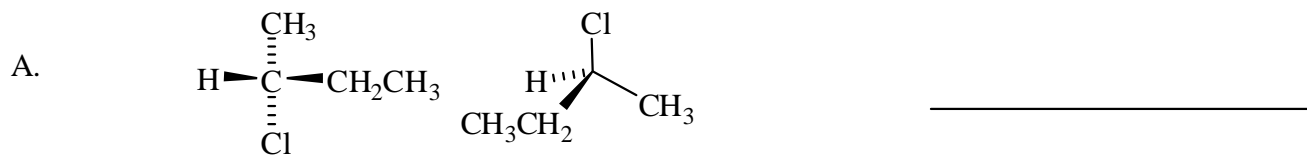


(only 1 product; no O in product)

X.

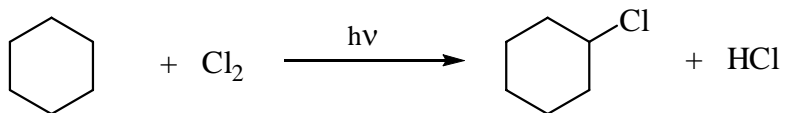


III. (15 pts) For each of the following pair of compounds, label them as enantiomers, diastereomers, or identical. These are not frozen structures. Rotation around any single bond is possible.

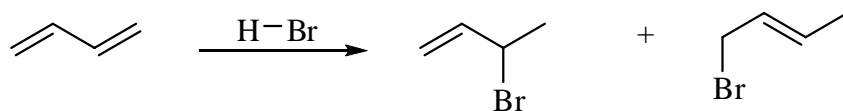


IV. (20 pts.) Draw a reasonable mechanism for **TWO** of the following three reactions. (If you do more than two, only A. and B. will be graded.)

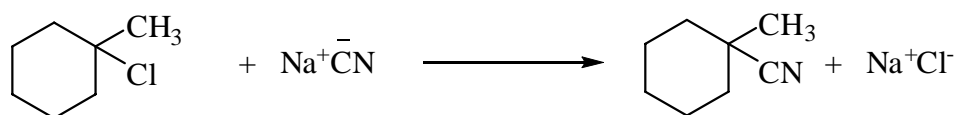
A.



B.



C.

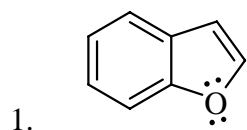


V. (9 pts.)

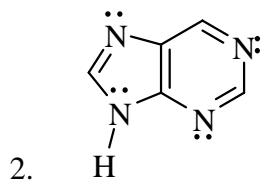
A. (5 pts) In the box provided draw the structure of an aromatic cation that has the formula  $C_9H_{11}^+$ .



B. (4 pts) How many  $\pi$  electrons are there for

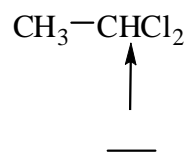
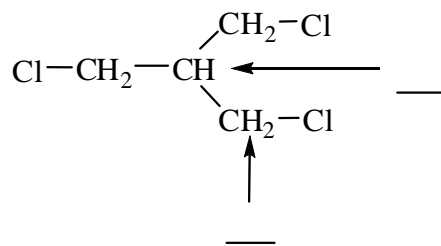
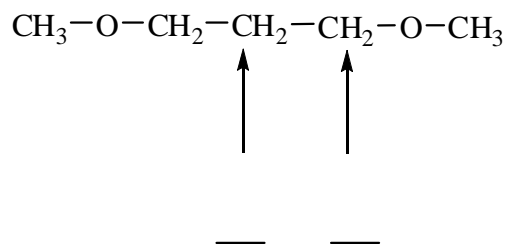
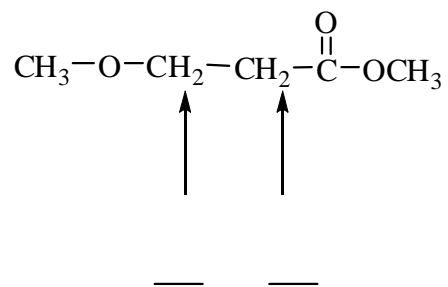


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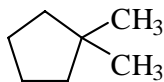
VI. (7 pts.) Into how many peaks will the signal for each of the indicated protons be split?  
(one = singlet, two = doublet, etc).



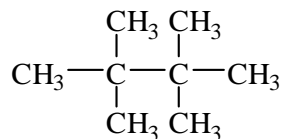
VII. (15 pts) Circle the correct answer.

A. The compound which would be most likely to give a mass spectrum with a prominent peak at  $m/e$  83 = is

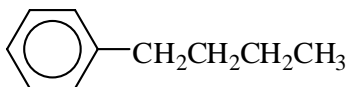
1.



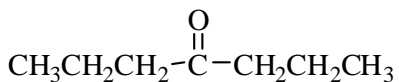
2.



3.

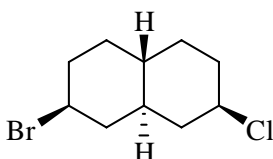


4.

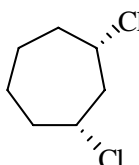


B. Which compound is a meso compound?

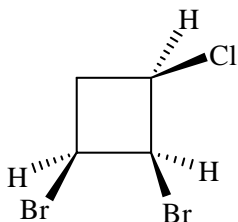
1.



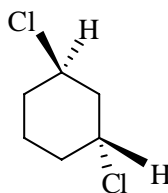
2.



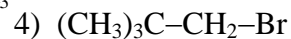
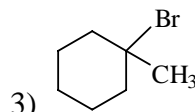
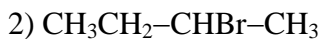
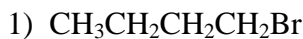
3.



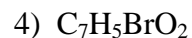
4.



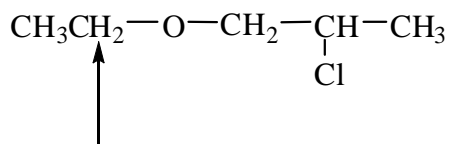
C. The most reactive alkyl halide in an  $S_N2$  reaction is



D. The molecular formula of *para*-bromostyrene is



E. The hydrogen atoms indicated by the arrow are:



a) homotopic

b) enantiotopic

c) diastereotopic

d) unrelated

VIII. (18 pts) For each of the following compounds, propose a structure in the box provided that fits the data presented.

A. (6 pts)  $C_6H_{11}Br$

$^1H$  NMR:

$\delta$  5.8 (1,m)

$\delta$  5.0 (2,m)

$\delta$  3.4 (2,t)

$\delta$  2.1 (2,m)

$\delta$  1.9 (2,m)

$\delta$  1.6 (2,m)

Broadband decoupled  $^{13}C$  NMR:

$\delta$  138.1

$\delta$  115.0

$\delta$  33.7

$\delta$  32.9

$\delta$  32.2

$\delta$  27.4

IR:  $3000\text{ cm}^{-1}$

B. (6 pts)  $C_7H_{14}O$

$^1H$  NMR:

$\delta$  2.4 (4,t)

$\delta$  1.6 (4, m)

$\delta$  0.9 (6,t)

Broadband decoupled  $^{13}C$  NMR:

$\delta$  211.2

$\delta$  45.0

$\delta$  17.6

$\delta$  14.0

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

C. (6 pts)  $C_8H_9BrO$

$^1H$  NMR

$\delta$  7.4 (2,d)

$\delta$  7.2 (2,d)

$\delta$  4.8 (1,q)

$\delta$  2.5 (1,s)

$\delta$  1.4 (3,d)

Broadband decoupled  $^{13}C$  NMR

$\delta$  144.7       $\delta$  121.0

$\delta$  131.4       $\delta$  69.6

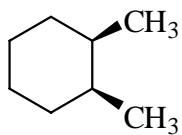
$\delta$  127.1       $\delta$  25.2

IR:  $3500\text{ cm}^{-1}$ ,  $1100\text{ cm}^{-1}$

(either of two isomers will get full credit)

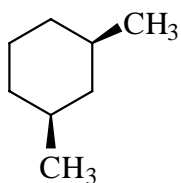
IX. (7 pts) How many  $^{13}\text{C}$  signals would each of the following compounds show? Put your answer in the blank provided.

A.



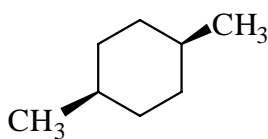
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B.



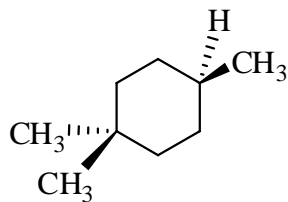
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C.



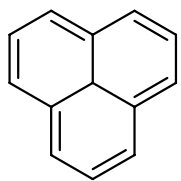
\_\_\_\_\_

D.



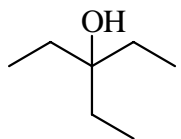
\_\_\_\_\_

E.



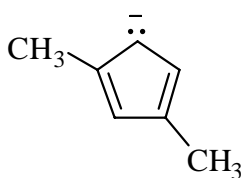
\_\_\_\_\_

F.



\_\_\_\_\_

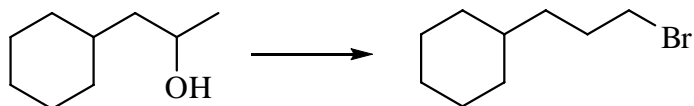
G.



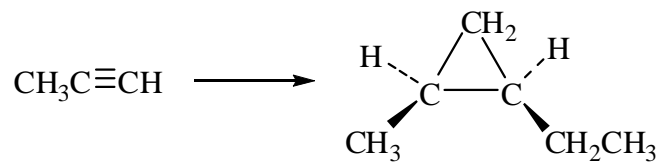
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X. (13 pts) Beginning with the starting material indicated, show how to achieve each of the following syntheses by showing all the reactions that are needed (for each reaction, give the starting material, conditions over the arrow, and the products). You may use any inorganic compound or organic compound with one or two carbon atoms.

A. (6 pts)



B. (7 pts)



**CHARACTERISTIC PROTON CHEMICAL SHIFTS**

Type of proton	Chemical shift $\delta$ , ppm
Cyclopropane	0.2
Primary	0.9
Secondary	1.3
Tertiary	1.5
Vinylc	4.6-5.9
Acetylenic	2-3
Aromatic	6-8.5
Benzylic	2.2-3
Allylic	1.7
Fluorides	4-4.5
Chlorides	3-4
Bromides	2.5-4
Iodides	2-4
Alcohols	3.4-4
Ethers	3.3-4
Esters	3.7-4.1
Esters	2-2.2
Acids	2-2.6
Carbonyl compounds	2-2.7
Aldehydic	9-10
Hydroxylic	1-5.5
Phenolic	4-12
Enolic	15-17
Carboxylic	10.5-12
Amino	1-5
DEPT 90	CH
DEPT 135	CH, CH <sub>3</sub> positive signal

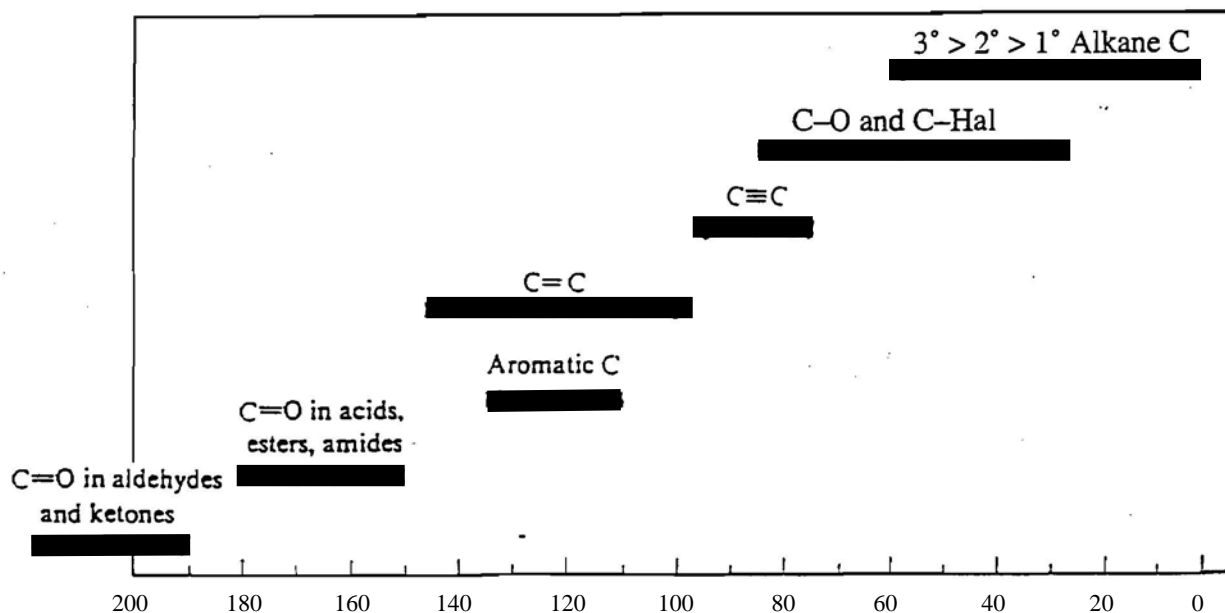
**CHARACTERISTIC INFRARED ABSORPTION FREQUENCIES**

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										3A		4A		5A		6A		7A		8A													
1 H 1.01	2A 2											13 Al 27.0	14 Si 28.1	15 P 31.0	16 S 32.1	17 Cl 35.5	18 Ar 39.9	2 He 4.00																	
3 Li 6.94	4 Be 9.01	3B 3	4B 4	5B 5	6B 6	7B 7	8	9	10	11	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.