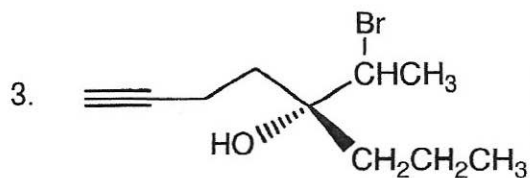
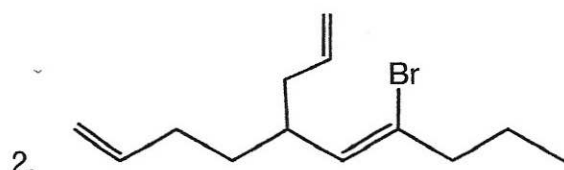
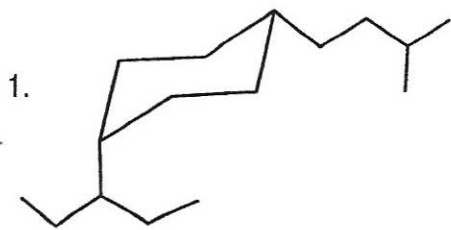


# Final Exam B

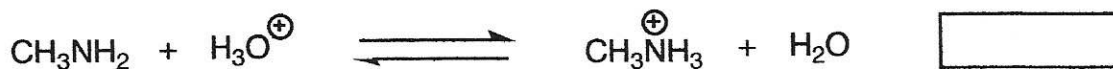
## A. Nomenclature: (12 points)

Give an acceptable IUPAC name for each compound. Be sure to indicate the **stereochemistry** where appropriate.

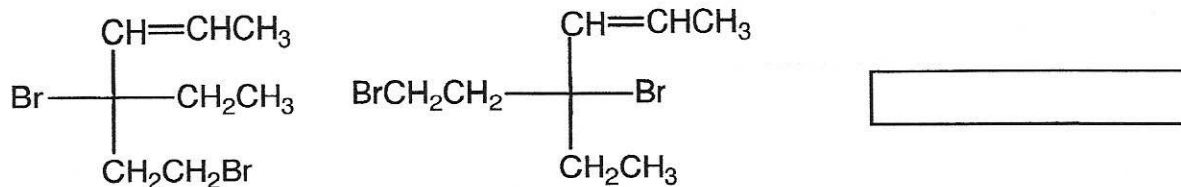


**B. Facts: 24 points**

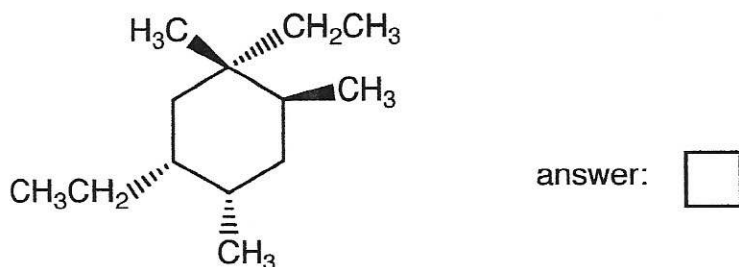
1. Does the following equilibrium lie to the Left or the Right? (2 pts.)



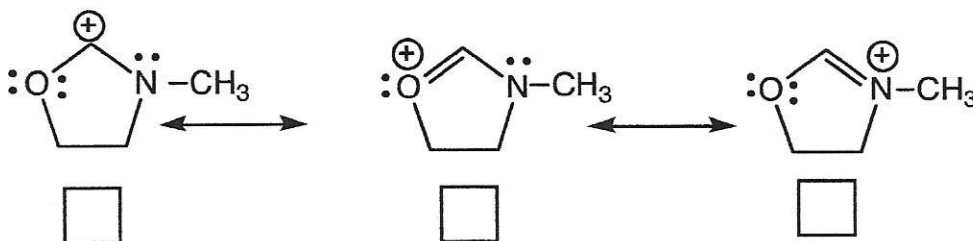
2. Label the following pair as identical, structural isomers, enantiomers or diastereomers. (2 pts.)



3. Consider the substituted cyclohexane below. In the more stable chair conformation, how many methyl groups are in **equatorial** positions? (2 pts.)



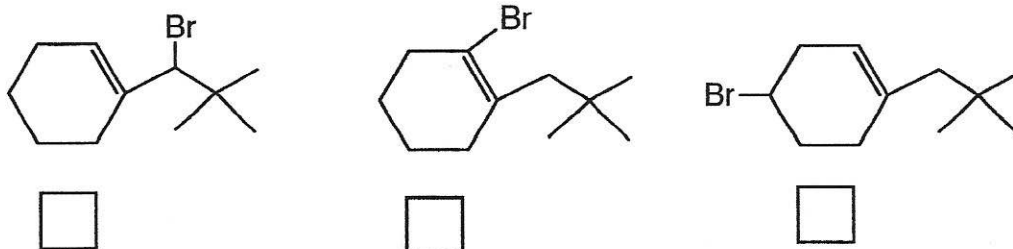
4. Consider the resonance contributors below.



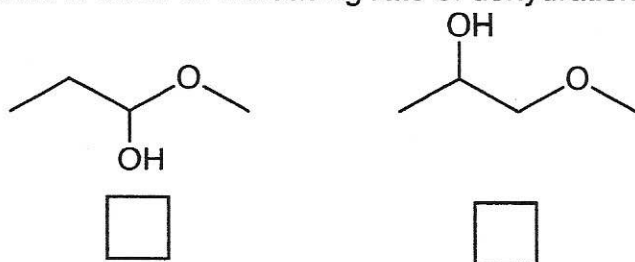
a. Place the contributors in order of increasing importance to the hybrid. (1=contributes least, 3=contributes most) (3 pts.)

b. Place the hybridization of the oxygen atom in the box. (2 pts.)

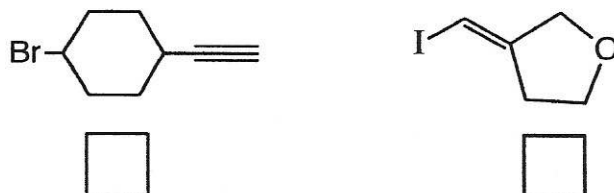
5. Consider the reaction rates of the compounds below with NaI in acetone and place in order of increasing reaction rate. (1=slowest rate, 3=fastest rate) (3 pts.)



6. Place the compounds in order of increasing rate of dehydration. (1=slower rate, 2=faster rate) (2pts.)



7. If the compound below can be used to form a Grignard reagent, place **Y** in the box. If it cannot, place **N** in the box. (2 pts.)



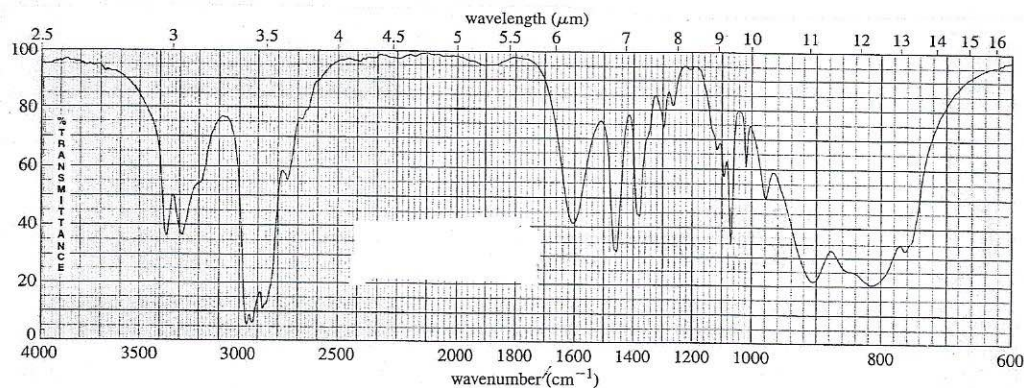
8. Carefully examine the spectrum and the compounds below. Place the letter of the correct compound in the box beside the spectrum. (2 pts.)

A  $(\text{CH}_3\text{CH}_2\text{CH}_2)_2\text{NH}$

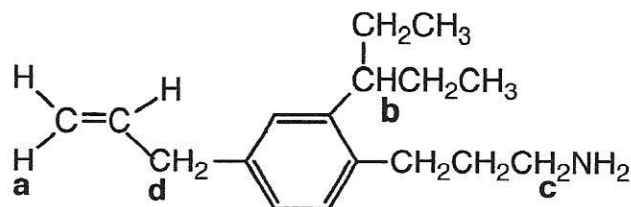
B  $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$

C  $\text{CH}_3\text{CH}_2\text{CH}_2\text{NH}_2$

D  $\text{CH}_3\text{CH}_2\text{CH}_2\text{CN}$



9. Answer the following questions for the molecule shown below and place the answers in the appropriate boxes. (i) What are the theoretically predicted multiplicities (splitting patterns) of the signals for the protons labeled **a** and **b**? (ii) Under ultrapure conditions, what is the theoretically predicted multiplicity of the signal for the proton labeled **c**? (iii) What is the theoretically predicted multiplicity of the signal for the carbon atom labeled **d** in the proton spin coupled C-13 NMR? (4 pts.)



(i) multiplicity of  $H_a$

multiplicity of  $H_b$

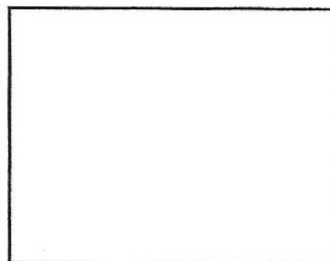
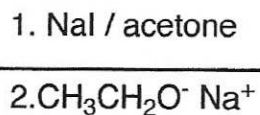
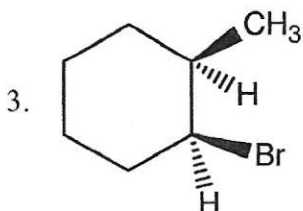
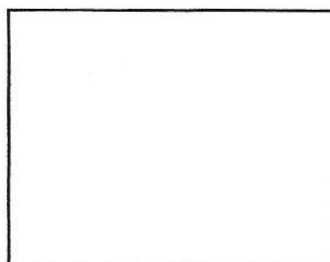
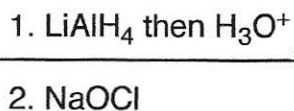
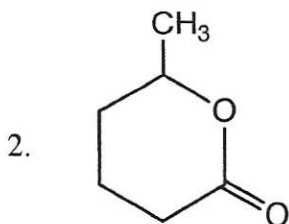
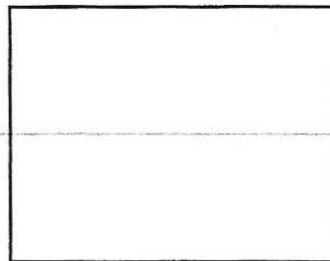
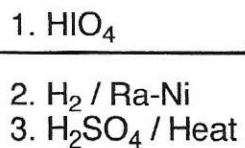
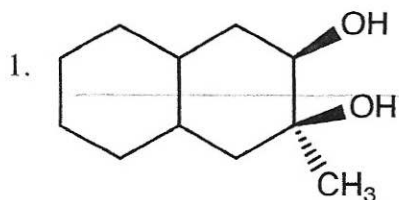
(ii) multiplicity of  $H_c$

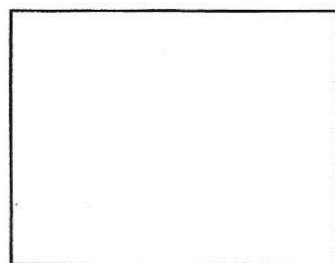
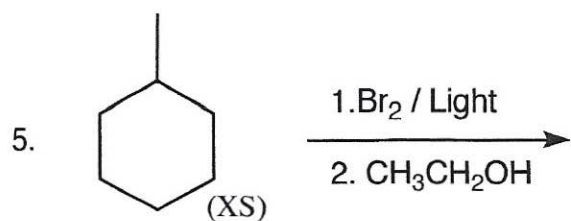
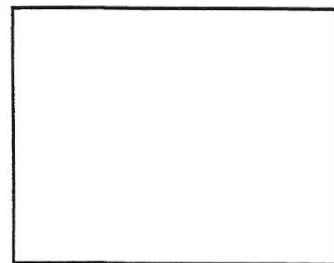
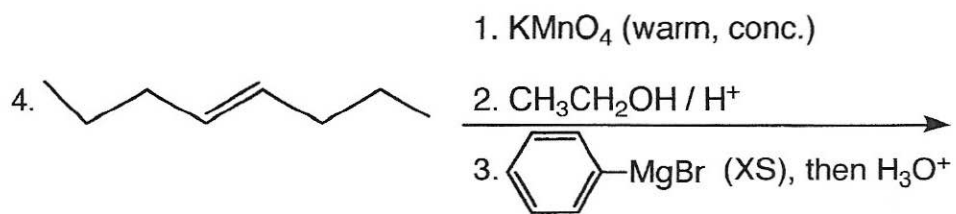
(iii) multiplicity of  $C_d$



**C. Reactions:** Total = 36 points, 4 points each

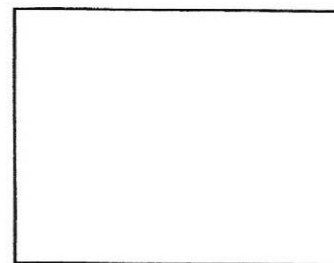
Please provide the major product in the answer box unless otherwise indicated. Indicate **stereochemistry** if applicable. **Full credit is awarded only when the product of each step in a multi-step reaction is shown below the reaction.**





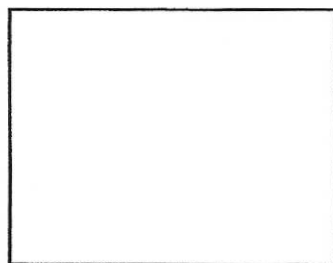
Major

+

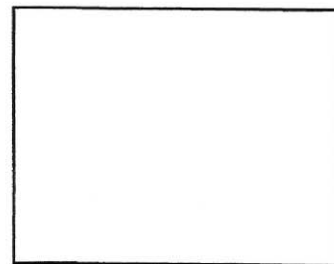
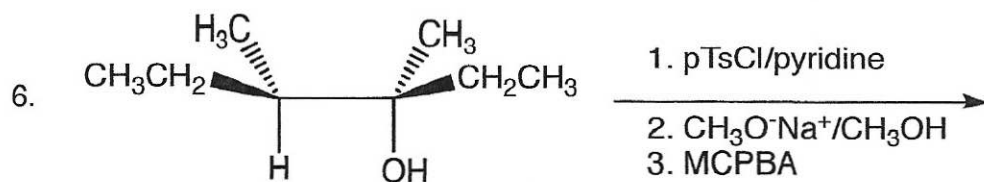


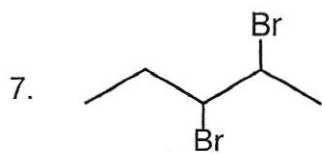
Minor

+



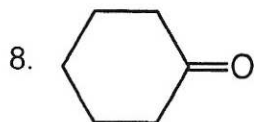
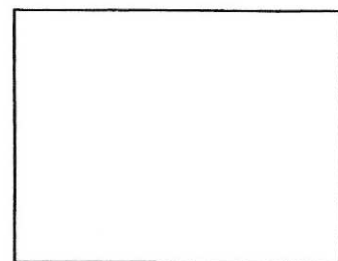
Minor





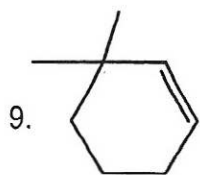
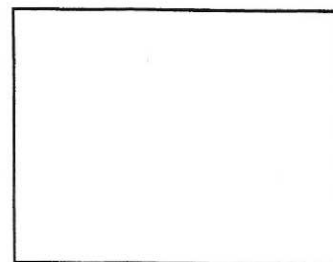
1.  $\text{NaNH}_2 / 150^\circ\text{C}$ , then  $\text{H}_3\text{O}^+$

2.  $\text{Si}_2\text{H}_6$   
 3.  $\text{H}_2\text{O}_2 / \text{OH}^-$   
 4.  $\text{NaBH}_4 / \text{EtOH}$   
 5.  $\text{POCl}_3$

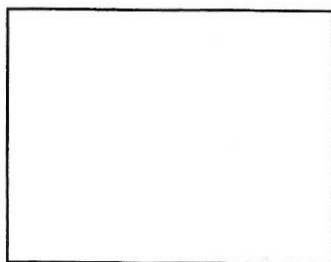


1.  $\text{CH}_3\text{C}\equiv\text{C} : ^- \text{Na}^+$ , then  $\text{H}_3\text{O}^+$

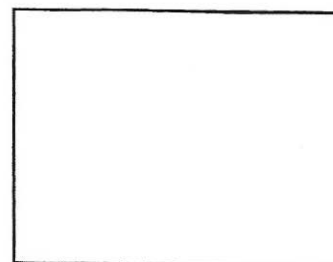
2.  $\text{H}_2 / \text{Pd}(\text{BaSO}_4) / \text{quinoline}$



NBS / Light

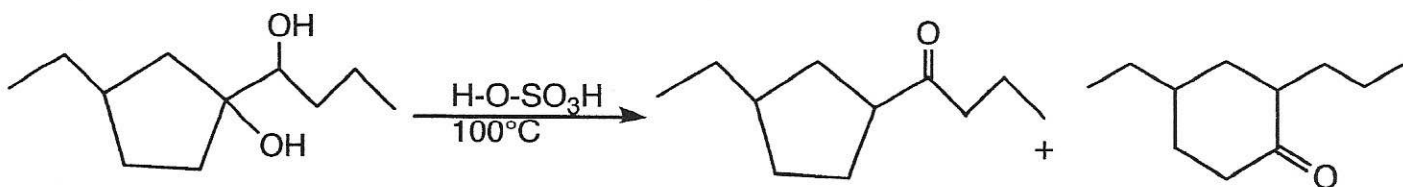


+



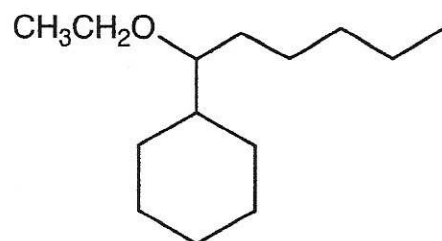
**D. Mechanisms: (10 points )**

The reaction below produces a mixture of products. Provide a clear mechanism to explain the formation of the products shown. Use curved arrows to indicate "electron flow". Remember to show only one step at a time. Show all intermediates and all formal charges. **If more than one resonance contributor is possible, be sure to show the more stable contributor.**



**E. Synthesis:** 10 Points

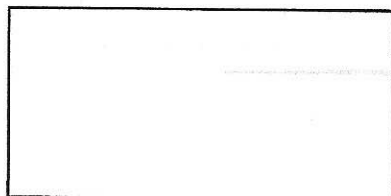
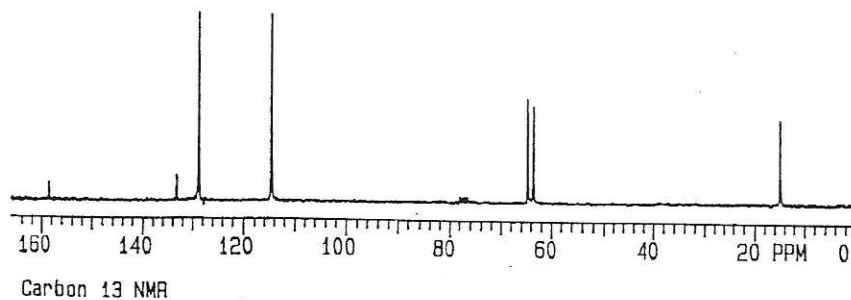
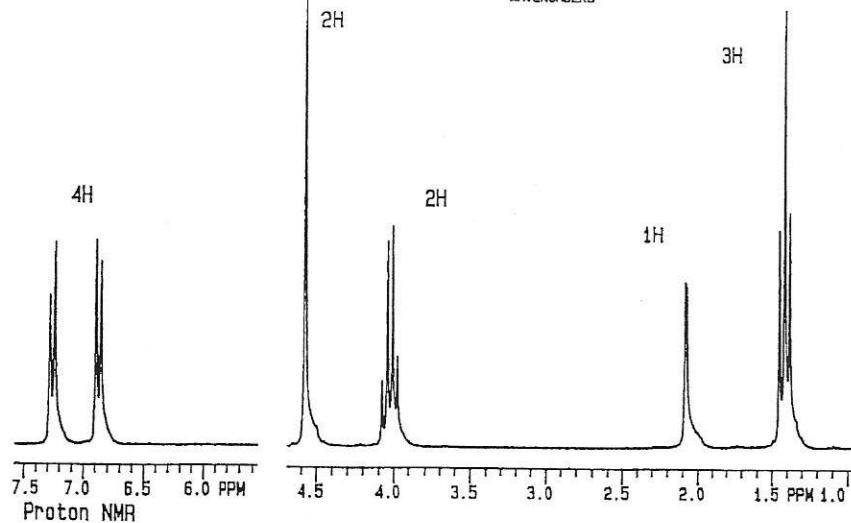
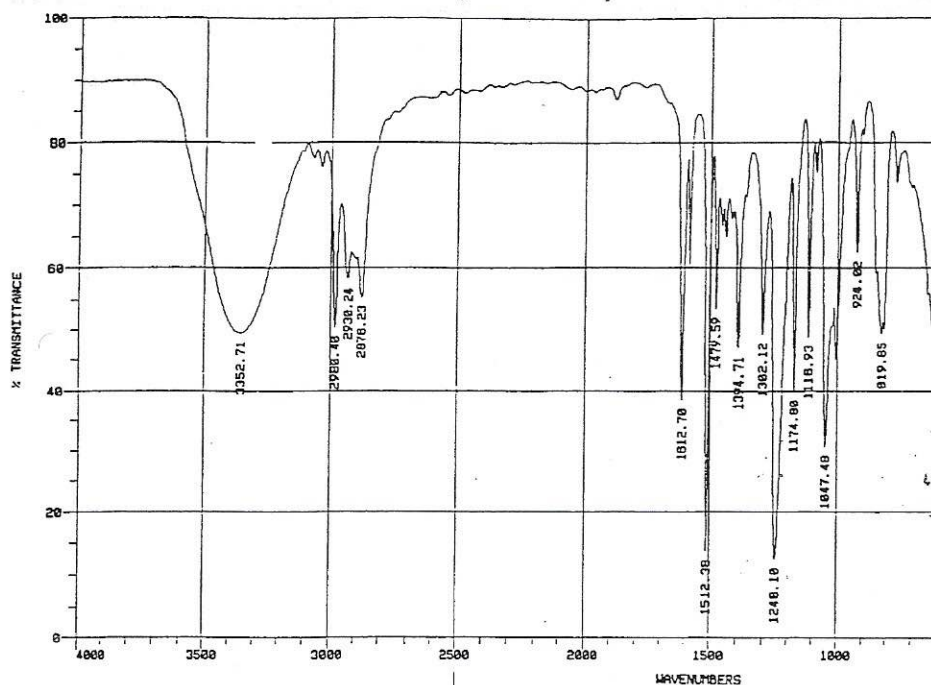
Synthesize the compound below using any of the following reagents: **cyclohexanol**, alcohols or alkenes of **four carbons or less**, any inorganic reagents, any peroxy acids, and any oxidizing or reducing agents.





### F. Spectroscopy: 8 Points

A compound with the formula  $C_{19}H_{12}O_2$  exhibits the IR,  $^1H$  NMR, and proton-spin decoupled  $^{13}C$  NMR spectra shown below. Please identify this compound and draw the structure in the box provided below.




**TABLE 13.3** Approximate proton chemical shifts

TYPE OF PROTON	CHEMICAL SHIFT ( $\delta$ , ppm)
1° Alkyl, RCH <sub>3</sub>	0.8–1.0
2° Alkyl, RCH <sub>2</sub> R	1.2–1.4
3° Alkyl, R <sub>3</sub> CH	1.4–1.7
Allylic, R <sub>2</sub> C=C—CH <sub>3</sub>   R	1.6–1.9
Ketone, RCCH <sub>3</sub>    O	2.1–2.6
Benzylic, ArCH <sub>3</sub>	2.2–2.5
Acetylenic, RC≡CH	2.5–3.1
Alkyl iodide, RCH <sub>2</sub> I	3.1–3.3
Ether, ROCH <sub>2</sub> R	3.3–3.9
Alcohol, HOCH <sub>2</sub> R	3.3–4.0
Alkyl bromide, RCH <sub>2</sub> Br	3.4–3.6
Alkyl chloride, RCH <sub>2</sub> Cl	3.6–3.8
Vinyllic, R <sub>2</sub> C=CH <sub>2</sub>	4.6–5.0
Vinylic, R <sub>2</sub> C=CH   R	5.2–5.7
Aromatic, ArH	6.0–9.5
Aldehyde, RCH    O	9.5–9.6
Alcohol hydroxyl, ROH	0.5–6.0 <sup>a</sup>
Amino, R—NH <sub>2</sub>	1.0–5.0 <sup>a</sup>
Phenolic, ArOH	4.5–7.7 <sup>a</sup>
Carboxylic, RCOH    O	10–13 <sup>a</sup>

<sup>a</sup> The chemical shifts of these protons vary in different solvents and with temperature and concentration.

**TABLE 13.4** Approximate carbon-13 chemical shifts

TYPE OF CARBON ATOM	CHEMICAL SHIFT ( $\delta$ , ppm)
1° Alkyl, RCH <sub>3</sub>	0–40
2° Alkyl, RCH <sub>2</sub> R	10–50
3° Alkyl, RCHR <sub>2</sub>	15–50
Alkyl halide or amine, —C—X (X = Cl, Br, or N—)	10–65
Alcohol or ether, —C—O	50–90
Alkyne, —C≡	60–90
Alkene, >C=	100–170
Aryl, 	100–170
Nitriles, —C≡N	120–130
Amides, —C(=O)—N—	150–180
Carboxylic acids, esters, —C(=O)—O	160–185
Aldehydes, ketones, —C(=O)—	182–215

**TABLE 13.2** Characteristic infrared absorptions of groups

GROUP	FREQUENCY RANGE (cm <sup>-1</sup> )	INTENSITY <sup>a</sup>
<b>A. Alkyl</b>		
C—H (stretching)	2853–2962	(m–s)
Isopropyl, —CH(CH <sub>3</sub> ) <sub>2</sub>	1380–1385 and 1365–1370	(s) (s)
<i>tert</i> -Butyl, —C(CH <sub>3</sub> ) <sub>3</sub>	1385–1395 and ~1365	(m) (s)
<b>B. Alkenyl</b>		
C—H (stretching)	3010–3095	(m)
C=C (stretching)	1620–1680	(v)
R—CH=CH <sub>2</sub>	985–1000 and 905–920	(s) (s)
R <sub>2</sub> C=CH <sub>2</sub>	880–900	(s)
<i>cis</i> -RCH=CHR	675–730	(s)
<i>trans</i> -RCH=CHR	960–975	(s)
	(out-of-plane C—H bendings)	
<b>C. Alkynyl</b>		
≡C—H (stretching)	~3300	(s)
C≡C (stretching)	2100–2260	(v)
<b>D. Aromatic</b>		
Ar—H (stretching)	~3030	(v)
Aromatic substitution type (C—H out-of-plane bendings)		
Monosubstituted	690–710 and 730–770	(very s) (very s)
<i>o</i> Disubstituted	735–770	(s)
<i>m</i> Disubstituted	680–725	(s)
<i>p</i> Disubstituted	750–810 and 800–840	(very s) (very s)
<b>E. Alcohols, Phenols, and Carboxylic Acids</b>		
O—H (stretching)		
Alcohols, phenols (dilute solutions)	3590–3650	(sharp, v)
Alcohols, phenols (hydrogen bonded)	3200–3550	(broad, s)
Carboxylic acids (hydrogen bonded)	2500–3000	(broad, v)
<b>F. Aldehydes, Ketones, Esters, and Carboxylic Acids</b>		
C=O (stretching)	1630–1780	(s)
Aldehydes	1690–1740	(s)
Ketones	1680–1750	(s)
Esters	1735–1750	(s)
Carboxylic acids	1710–1780	(s)
Amides	1630–1690	(s)
<b>G. Amines</b>		
N—H	3300–3500	(m)
<b>H. Nitriles</b>		
C≡N	2220–2260	(m)

<sup>a</sup> Abbreviations: s = strong, m = medium, w = weak, v = variable, ~ = approximately.