

### CHARACTERISTIC PROTON CHEMICAL SHIFTS

Type of proton	Chemical shift $\delta$ , ppm	
Cyclopropane	0.2	
Primary	H   RC—H	0.9
	H   H	
Secondary	R <sub>2</sub> C—H	1.3
Tertiary	R <sub>3</sub> C—H	1.5
Vinyllic	C=C—H	4.6-5.9
Acetylenic	C $\equiv$ C—H	2-3
Aromatic	Ar—H	6-8.5
Benzylic	Ar—C—H	2.2-3
Allylic	C=C—C—H	1.7
Fluorides	H—C—F	4-4.5
Chlorides	H—C—Cl	3-4
Bromides	H—C—Br	2.5-4
Iodides	H—C—I	2-4
Alcohols	H—C—OH	3.4-4
Ethers	H—C—OR	3.3-4
Esters	RCOO—C—H	3.7-4.1
Esters	H—C—COOR	2-2.2
Acids	H—C—COOH	2-2.6
Carbonyl compounds	H—C—C=O	2-2.7
Aldehydic	H   RC=O	9-10
	Hydroxylic	RO—H
Phenolic	ArO—H	4-12
Enolic	C=C—O—H	15-17
Carboxylic	RCOO—H	10.5-12
	H   RN—H	1-5
DEPT 90	CH	
DEPT 135	CH, CH <sub>3</sub> positive signal CH <sub>2</sub> negative signal	

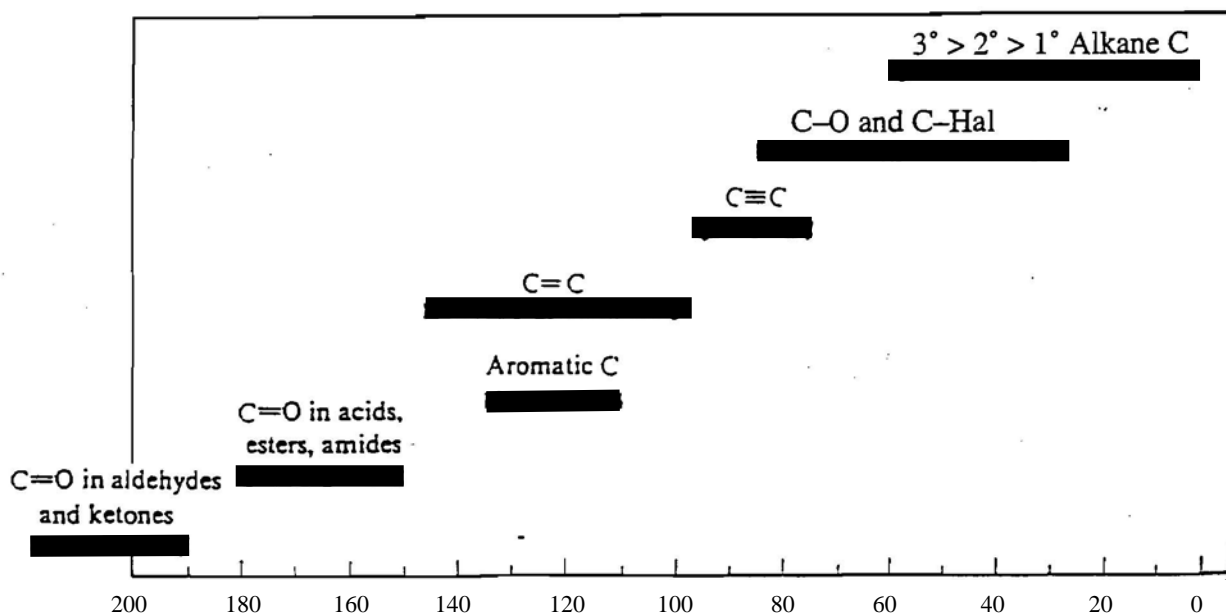
### CHARACTERISTIC INFRARED ABSORPTION FREQUENCIES

Bond	Compound type	Frequency range, cm <sup>-1</sup>
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 $\equiv$ 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
	Carboxylic acids	2500-3000 ( <i>broad</i> )
N—H	Amines	3300-3500 ( <i>m</i> )
C—N	Amines	1180-1360
C $\equiv$ 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 He	
H 1.01																		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	1B 11	2B 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.