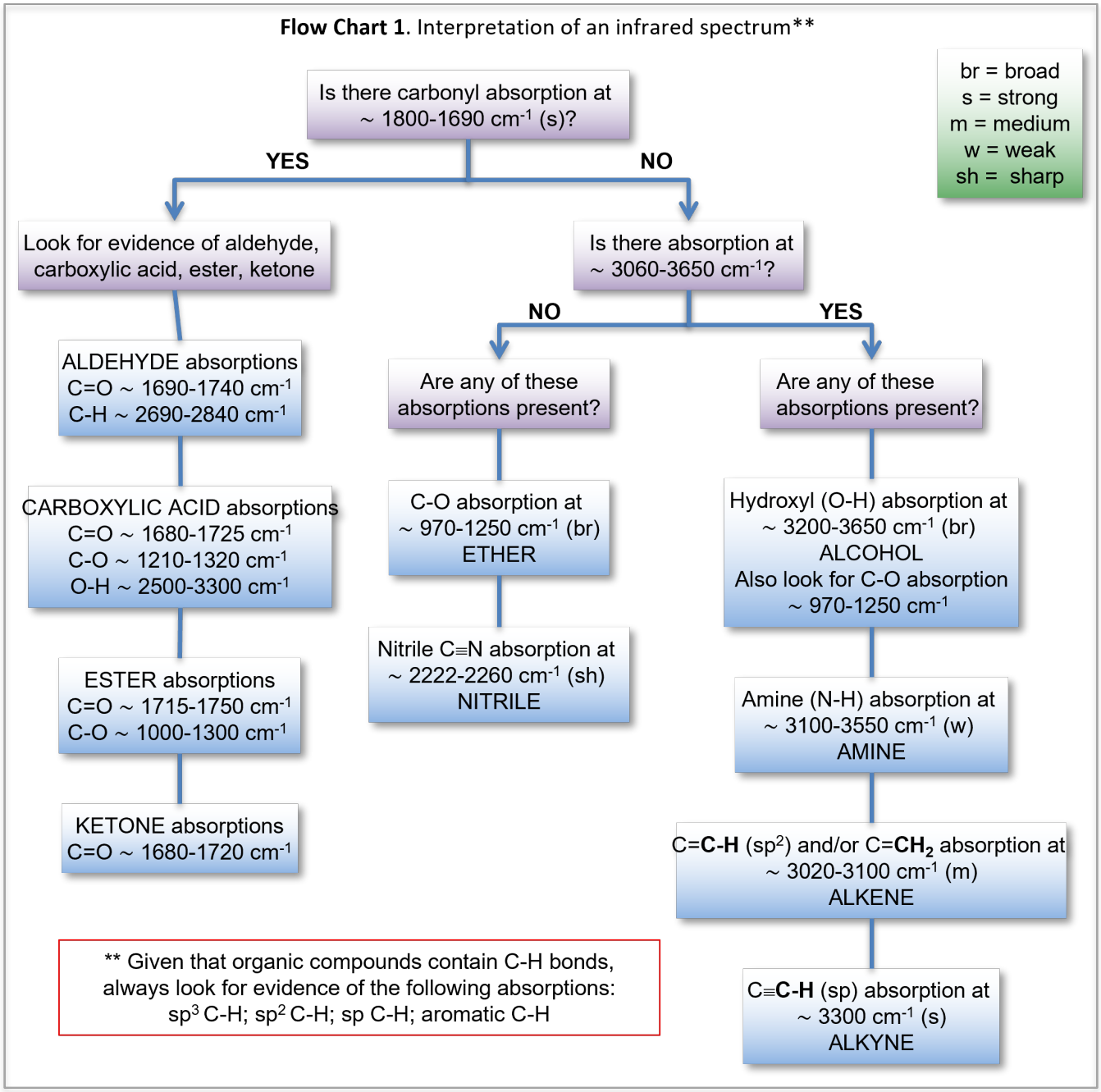
Infrared Absorption Frequencies of Specific Functional Groups[1,2,3,4]

Class of compound	Stretching Vibrations and Bending Vibrations				Comments
	Functional group or bond	Approximate frequencies (cm^{-1})	Intensity / shape*	Additional information	
Alkane	C-**C-H** (sp^3) Groups: Isopropyl $-CH(CH_3)_2$ *tert*-butyl $-C(CH_3)_3$	2850-3000 1380-1385 and 1365-1370 1385-1395 and ~1365	s s, s m, s	2 or 3 bands	Saturated hydrocarbons give simple spectra, with few absorptions. The isopropyl group shows a strong doublet with peaks of almost equal intensity. In the *t*-butyl doublet, the long wavelength band is more intense.
Alkene	C=**C-H** (sp^2) **RCH=CH₂** (vinyl) R_2C**=C**H_2 (vinylidene) *cis*-**RCH=CHR** *trans*-**RCH=CHR**	3020-3100 985-995 and 905-915 885-895 665-730 960-980	m s, s s s s	multiple bands possible	These C-H bending vibrations given are some of the more prominent and reliable ones.
	C=C RCH=**C**H_2 (vinyl) R_2**C=C**H_2 (vinylidene) *cis*-RCH=**C**HR *trans*-RCH=**C**HR	1600-1680 1638-1648 1648-1658 1626-1662 1668-1678	var --- m var var	2 bands if unsymmetrical conjugated alkene	The absorption intensity is reduced when the C=C is symmetric. Completely symmetrical alkenes do not present a C=C stretching absorption. Unsymmetrical conjugated alkenes display two bands, however symmetrical conjugated alkenes display only one band.
Alkyne	C≡**C-H** (sp)	3300	s / sh		The absorption intensity is reduced when the C≡C is symmetric. For internal alkynes, the C≡C absorption is weak or even absent.
	C≡C	2100-2260	var		
Aromatic	C=**C-H** (sp^2 arom) C=**C-H** (sp^2 arom) *Aromatic substitution* monosubstituted *o*-disubstituted *m*-disubstituted *p*-disubstituted	3030 900-1300 690-710 and 730-770 735-770 675-725 and 750-810 800-900	var m, m s, s s s, s s	multiple bands possible 2 bands (in-plane bending) out-of-plane bending out-of-plane bending out-of-plane bending out-of-plane bending	The out-of-plane bending vibrations are usually reliable for alkylbenzenes. However, when polar groups are attached directly to the benzene ring, e.g. nitrobenzenes, as well as aromatic acids, esters and amides, these bands must be interpreted with caution.
	C=C (sp^2 arom)	1400-1600	m, w	2 bands (3 if conjugated)	
Alcohol & Phenol	O-H (free)	3580-3700	var / sh		The O-H (free) band is observed in dilute solution in nonpolar solvents. The O-H (H-bonded) band is broad due to intermolecular H-bonding in more concentrated solutions. Neat alcohols absorb near 3300 cm^{-1}. The position of the C-O stretching absorption varies for 1º, 2º or 3º alcohols as well as for phenols.
	O-H (H-bonded)	3200-3550	s / br		
	C-O **C-O** 1º **C-O** 2º **C-O** 3º **C-O** phenol	970-1260 1050-1085 1087-1124 1124-1205 1180-1260	s s s s s		
Ether	**C-O** **C-O** (arom)	1085-1150 (usually at 1125) 1020-1275	s	2 bands	Aromatic ethers have two bands at ~1030 and ~1245 cm^{-1}.
Aldehyde	C-H (may overlap C-H alkane)	2695-2830	m / sh	2 bands	The higher frequency C-H stretching absorption of the aldehyde group (2840 cm^{-1}) may be obscured by the alkane (aliphatic) sp^3 C-H stretching absorption. Carbonyl stretching for aromatic aldehydes is at a lower frequency than aliphatic aldehydes. Conjugation with the aromatic ring lowers its frequency.
	C=O **C=O** (arom)	1720-1740 1690-1715	s		
Ketone	**C=O** **C=O** (arom)	1705-1720 1680-1700	s		Conjugation decreases the frequency of the carbonyl stretching.
Carboxylic Acid	**C=O** **C=O** (arom)	1700-1725 1680-1700	s / br		Carboxylic acids have a very broad O-H stretching absorption that may obscure C-H stretching absorptions. The carbonyl stretching is broad. Conjugation lowers the absorption frequency of the carbonyl group.
	O-H (may overlap C-H alkane)	2500-3300 (usually at 3000)	s / v br		
	C-O	1210-1320	s, m	2 bands	
Carboxylate Anion	C=**O**$^{\ominus}$	1550-1650 and 1400	s, w		
Ester	**C=O** **C=O** (arom)	1735-1750 1715-1730	s		There are two C-O stretching absorptions. One is generally stronger that the other. Conjugation lowers the absorption frequency of the carbonyl group.
	C-O **C-O** (methyl esters of long-chain fatty acids)	1000-1300 1175 and 1205 and 1250	m or s m, m, s	2 bands 3 bands	
Amide	**C=O** 1º (solution) **C=O** 2º **C=O** 3º	1630-1695	s	2 bands (1 band if solid) 1 band 1 band	1º amides show two C=O and two N-H stretching bands, while 2º amides show only one C=O band and one N-H band. 3º amides display one C=O band, but do not absorb in the N-H stretching region. The carbonyl stretching frequency is decreased by resonance.
	N-H 1º (solution) **N-H** 2º and **lactam**	3060-3550	m, m m	2 bands (1 band if solid) 1 band	
Anhydride	**C=O**	1740-1790 and 1800-1850	s		Anhydrides give two strong carbonyl bands, one for symmetric stretching and the other for asymmetric stretching.
	C-O	900-1300	s	1 band (unconjugated aliphatic), 2 bands (cyclic anhydrides)	
Nitrile	**C≡N** **C≡N** (conj)	2240-2260 2222-2240	m / sh		Conjugation decreases the absorption frequency to 2222-2240 cm^{-1}.
Amine	**N-H** 1º	3400-3550	m, w	2 bands	1º amines present two N-H absorption bands that may overlap in the region 3250-3550 cm^{-1}, while 2º amines have only one band in this region. 3º amines do not absorb in this region.
	N-H 2º	3250-3400	w	1 band	
	C-N **C-N** (arom)	1000-1250 1266-1342	m w or m		

*s = strong; m = medium; var = variable; w = weak; br = broad; sh = sharp (narrow); arom = aromatic; conj = conjugated

Given that organic compounds contain C-H bonds, always look for evidence of the absorptions in the list below. In general, C-H stretching bands above 3000 cm^{-1} result from alkene, alkyne, aromatic and heteroaromatic C-H stretching.

- sp^3 C-H stretch between 2850-3000 cm^{-1}.
- sp^2 C-H stretch between 3020-3100 cm^{-1}
- sp C-H stretch at ~ 3300 cm^{-1}
- aromatic C-H stretch at ~ 3030 cm^{-1}



References

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