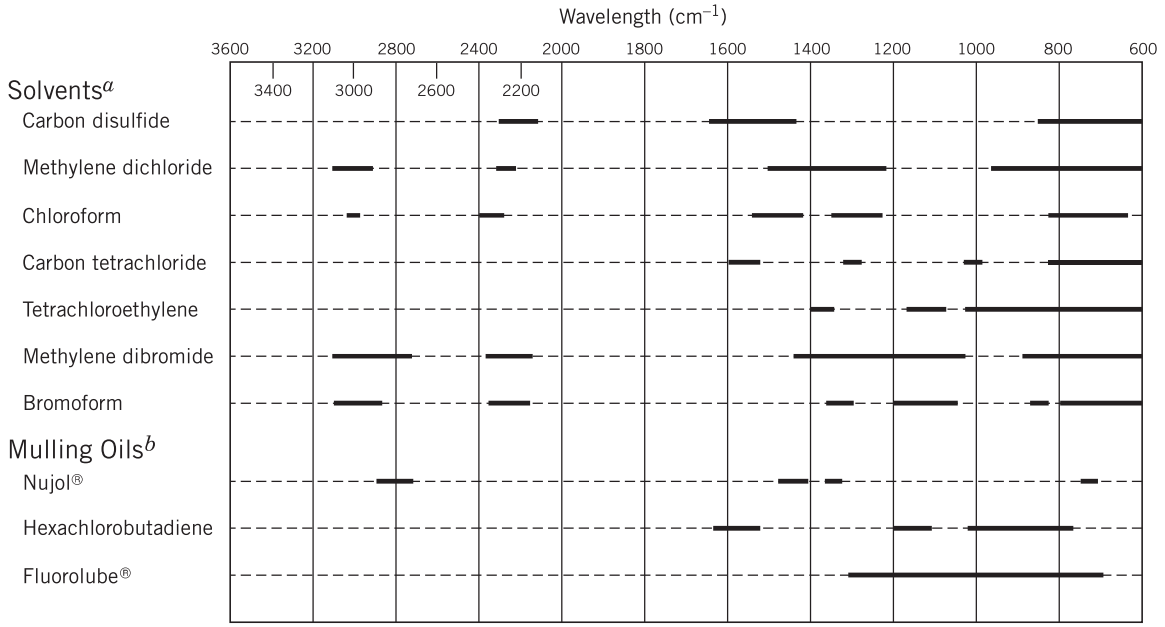
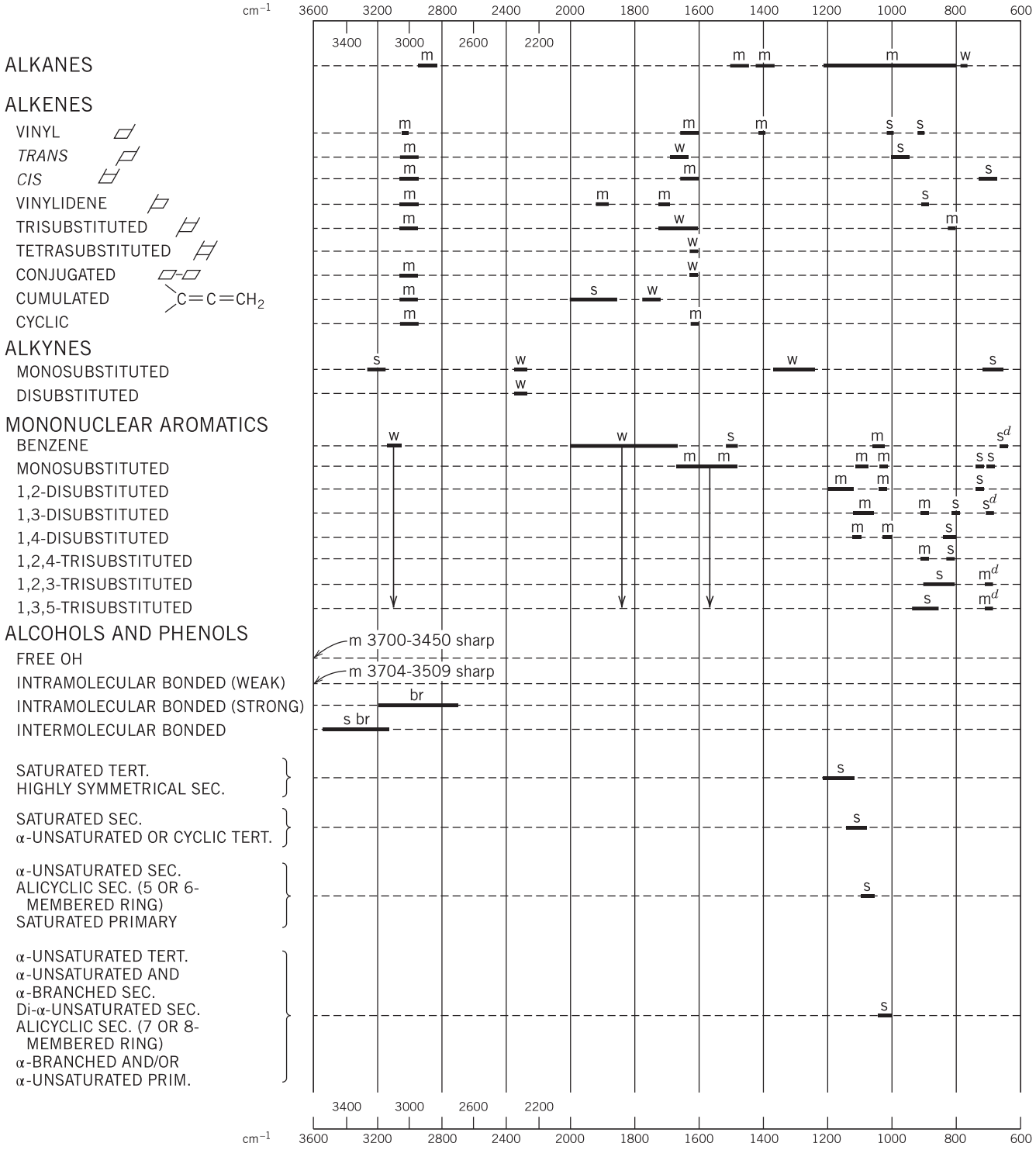
CHART AND SPECTRAL PRESENTATIONS OF ORGANIC SOLVENTS, MULLING OILS, AND OTHER COMMON LABORATORY SUBSTANCES

APPENDIX A TRANSPARENT REGIONS OF SOLVENTS AND MULLING OILS



[a] The open regions are those in which the solvent transmits more than 25% of the incident light at 1 mm thickness.
[b] The open regions for mulling oils indicate transparency of thin films.

APPENDIX B CHARACTERISTIC GROUP ABSORPTIONS[a]



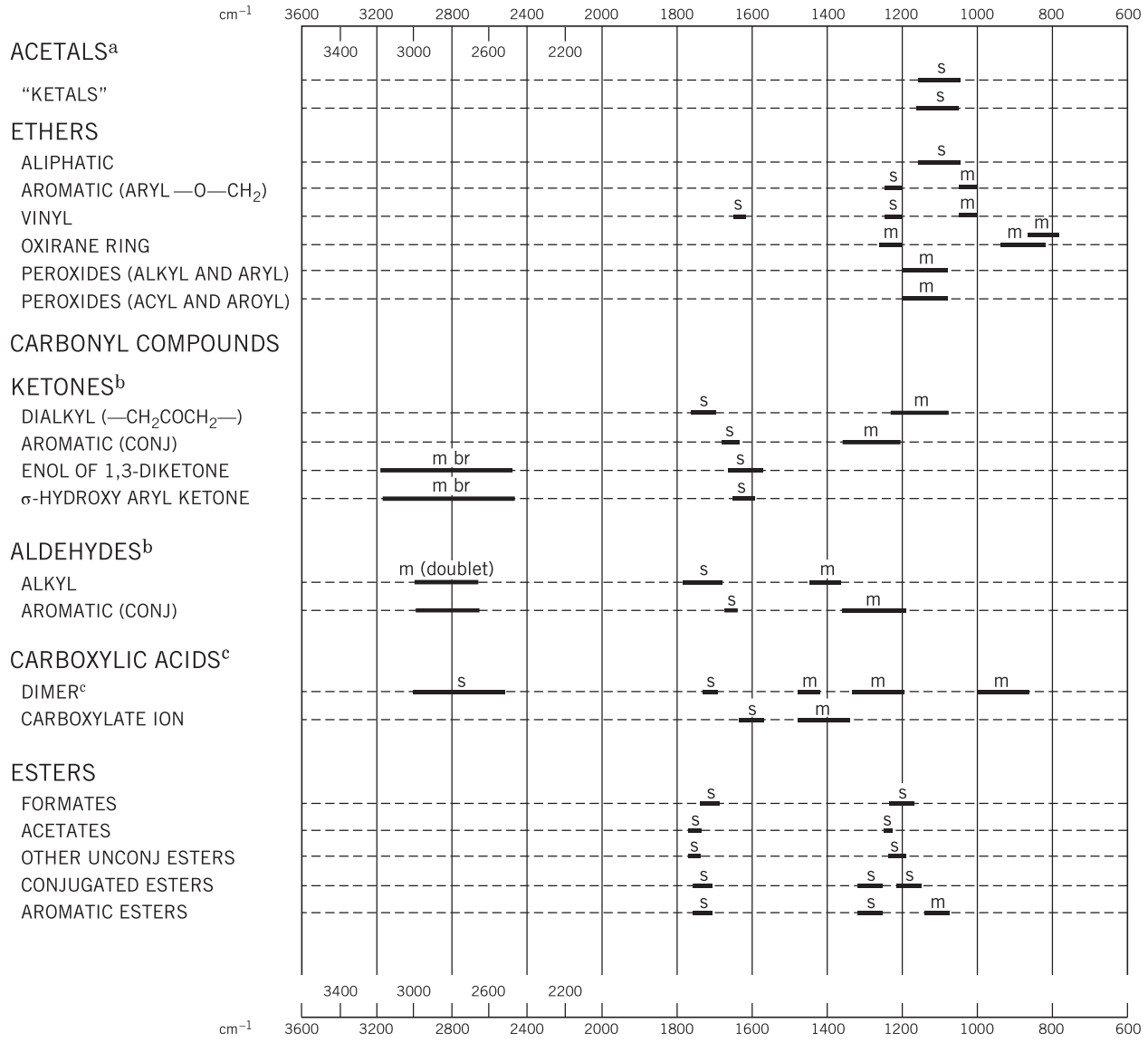
[a] Absorptions are shown by heavy bars. s = strong, m = medium, w = weak, sh = sharp, br = broad. Two intensity designations over a single bar indicate that two peaks may be present.

[b] May be absent.

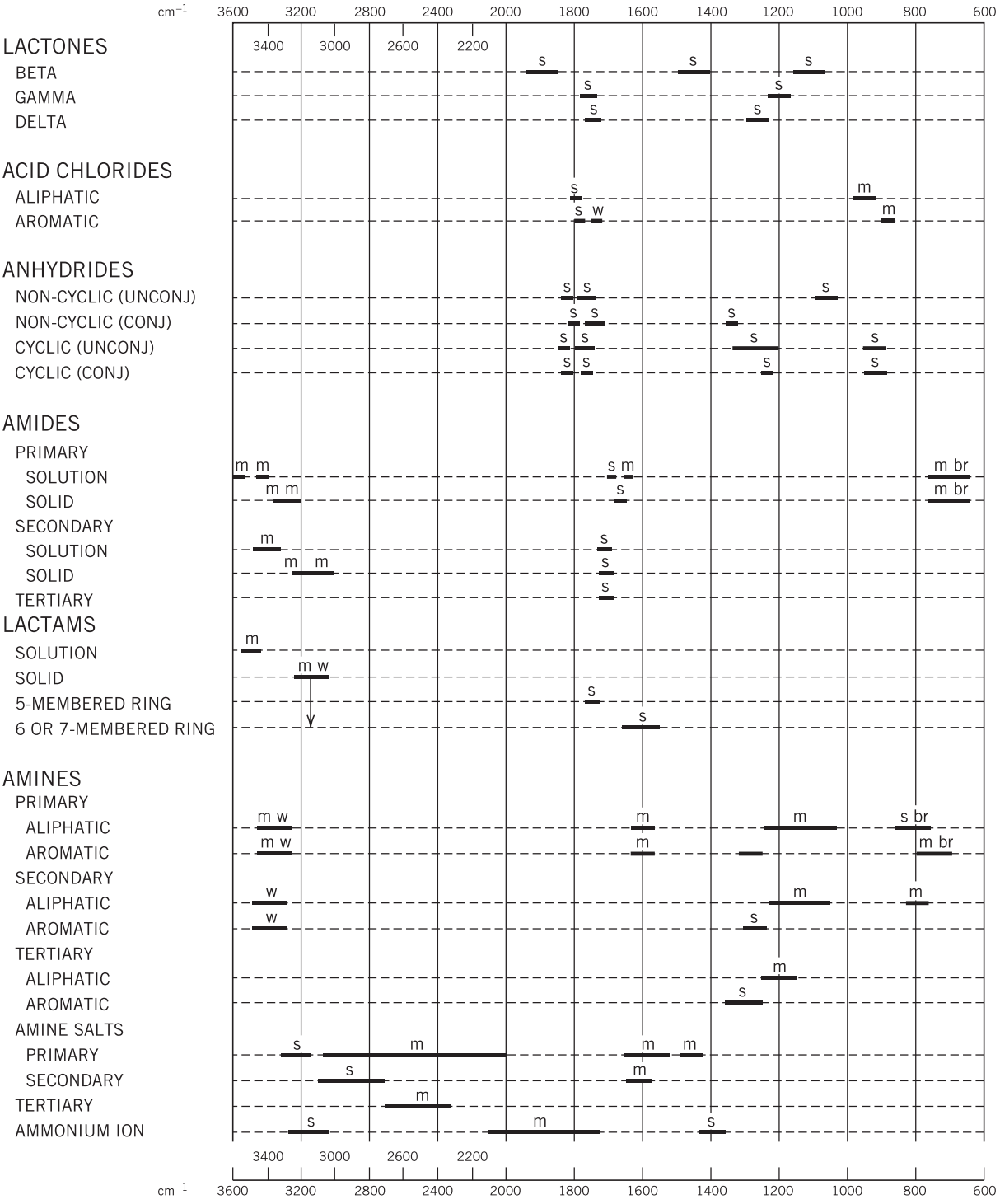
[c] Frequently a doublet.

[d] Ring bending bands.

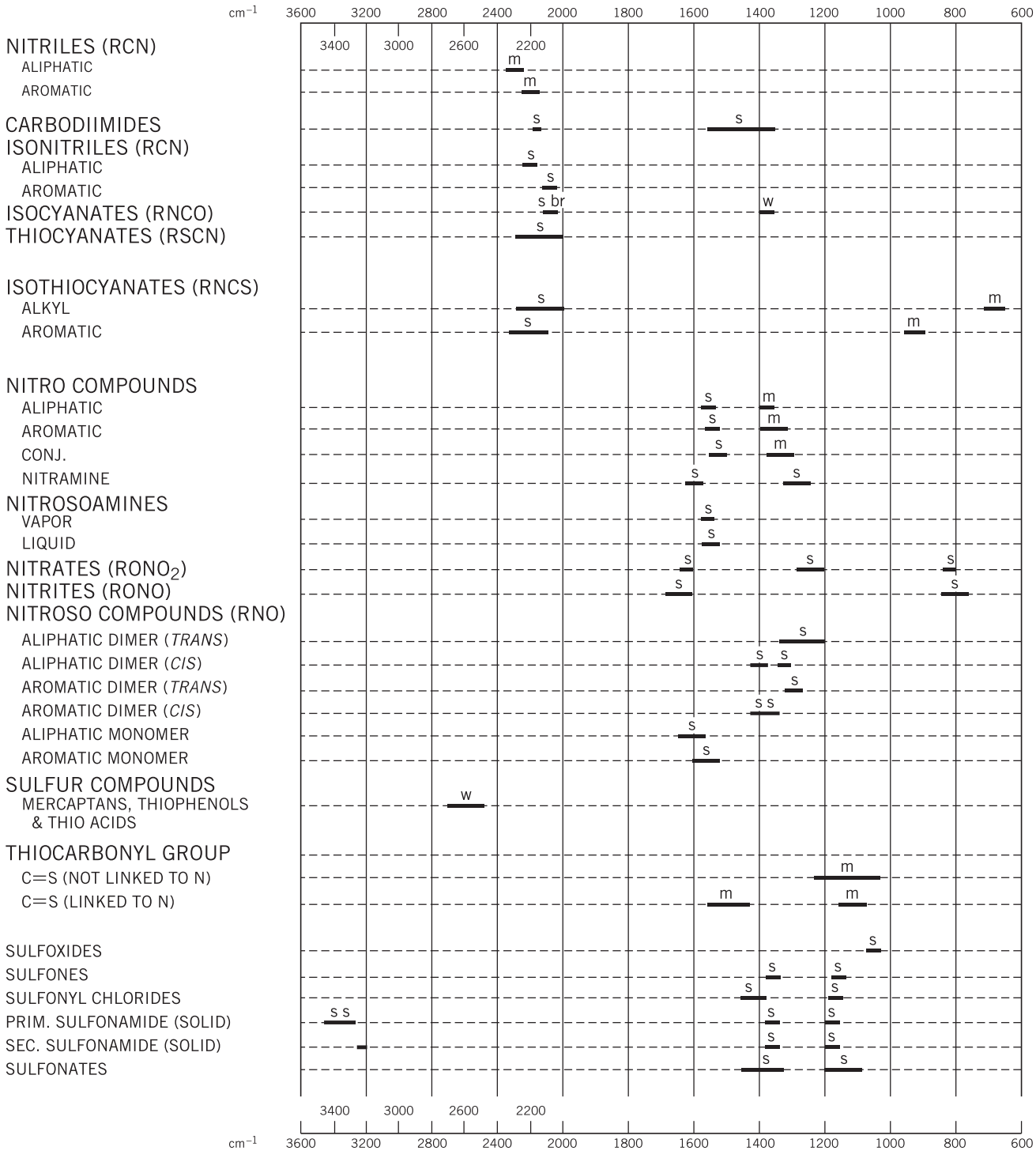
APPENDIX B (*continued*)

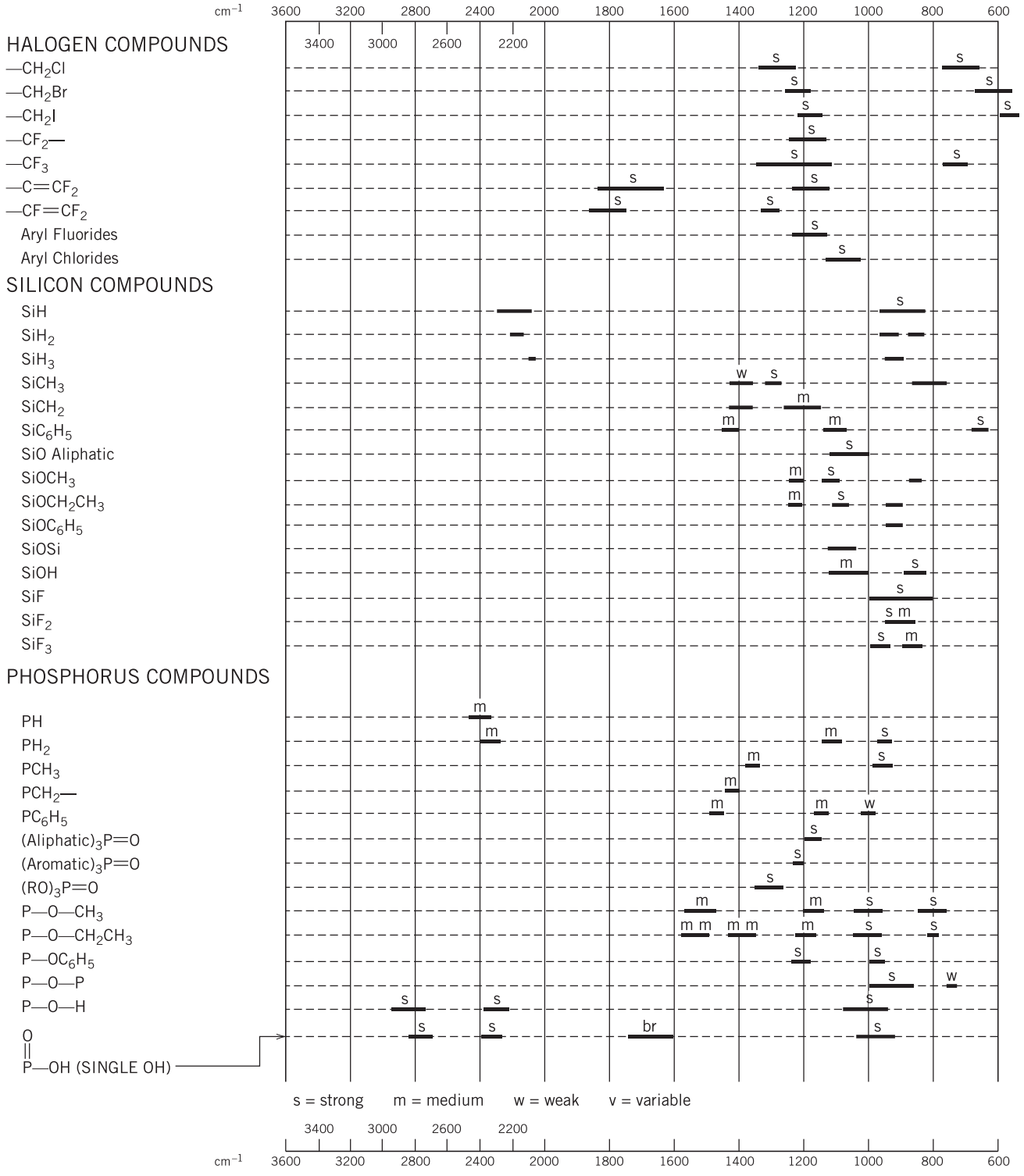


[a] Three bands, sometimes a fourth for ketals, and a fifth band for acetals.
[b] Conjugated aliphatic examples show C═O stretch at virtually the same position as aromatic structures.
[c] Conjugated examples show C═O stretch at lower wavenumbers (1710 cm^{-1} to 1680 cm^{-1}). The O—H stretch (3300 cm^{-1} to 2600 cm^{-1}) is very broad.


cm⁻¹
3600 3200 2800 2400 2000 1800 1600 1400 1200 1000 800 600
3400 3000 2600 2200
LACTONES
BETA
GAMMA
DELTA
ACID CHLORIDES
ALIPHATIC
AROMATIC
ANHYDRIDES
NON-CYCLIC (UNCONJ)
NON-CYCLIC (CONJ)
CYCLIC (UNCONJ)
CYCLIC (CONJ)
AMIDES
PRIMARY
SOLUTION
SOLID
SECONDARY
SOLUTION
SOLID
TERTIARY
LACTAMS
SOLUTION
SOLID
5-MEMBERED RING
6 OR 7-MEMBERED RING
AMINES
PRIMARY
ALIPHATIC
AROMATIC
SECONDARY
ALIPHATIC
AROMATIC
TERTIARY
ALIPHATIC
AROMATIC
AMINE SALTS
PRIMARY
SECONDARY
TERTIARY
AMMONIUM ION

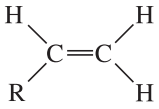
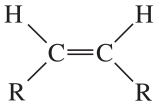
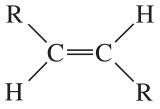
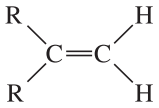
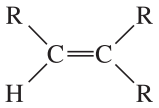
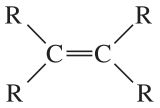
APPENDIX B (*continued*)




cm⁻¹
3600 3200 2800 2400 2000 1800 1600 1400 1200 1000 800 600
3400 3000 2600 2200
HALOGEN COMPOUNDS
—CH2Cl
—CH2Br
—CH2I
—CF2—
—CF3
—C=CF2
—CF=CF2
Aryl Fluorides
Aryl Chlorides
SILICON COMPOUNDS
SiH
SiH2
SiH3
SiCH3
SiCH2
SiC6H5
SiO Aliphatic
SiOCH3
SiOCH2CH3
SiOC6H5
SiOSi
SiOH
SiF
SiF2
SiF3
PHOSPHORUS COMPOUNDS
PH
PH2
PCH3
PCH2—
PC6H5
(Aliphatic)3P=O
(Aromatic)3P=O
(RO)3P=O
P—O—CH3
P—O—CH2CH3
P—OC6H5
P—O—P
P—O—H
O
||
P—OH (SINGLE OH)
s = strong m = medium w = weak v = variable
br

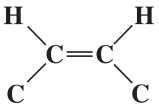
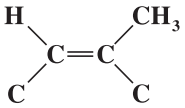
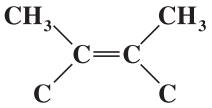
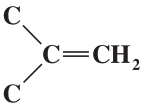
APPENDIX C ABSORPTIONS FOR ALKENES

TABLE C-1 Alkene Absorption[a]

		
Vinyl 1648 cm^{-1} to 1638 cm^{-1} 995 cm^{-1} to 985 cm^{-1} (s)[b] 915 cm^{-1} to 905 cm^{-1} (s)	*cis* 1662 cm^{-1} to 1626 cm^{-1} (v) 730 cm^{-1} to 665 cm^{-1} (s)	*trans* 1678 cm^{-1} to 1668 cm^{-1} (v) 980 cm^{-1} to 960 cm^{-1} (s)[c]
		
Vinylidene 1658 cm^{-1} to 1648 cm^{-1} (m) 895 cm^{-1} to 885 cm^{-1} (s)	Trisubstituted 1675 cm^{-1} to 1665 cm^{-1} (w) 840 cm^{-1} to 790 cm^{-1} (m)	Tetrasubstituted 1675 cm^{-1} to 1665 cm^{-1} very weak or absent

[a] s = strong, m = medium, w = weak, v = variable.
[b] This band also shows a strong overtone band.
[c] This band occurs near 1000 cm^{-1} in conjugated *trans–trans* systems such as the esters of sorbic acid.

TABLE C-2 C═C Stretching Frequencies in Cyclic and Acyclic Systems (cm^{-1})

Ring[a] or Chain				
Chain *cis*	1661	1681	1672	1661
Chain *trans*	1676			
Three-membered ring	1641		1890	1780
Four-membered ring	1566		1685	1678
Five-membered ring	1611	1658	1686	1657
Six-membered ring	1649	1678	1685	1651
Seven-membered ring	1651	1673		
Eight-membered ring	1653			

[a] All rings have *cis* double bonds.

APPENDIX D ABSORPTIONS FOR PHOSPHORUS COMPOUNDS

TABLE D-1 P═O and P—O Stretching Vibrations

Group	Wavenumber (cm^{-1})[a]	ν_{P-O} Bands[a] (cm^{-1})
P═O stretch		
Phosphine oxides		
Aliphatic	~1150	
Aromatic	~1190	
Phosphate esters[b]	1299 to 1250	
P—OH	1040 to 910 (s)	
P—O—P	1000 to 870 (s)	~700 (w)
P—O—C (aliph)	1050 to 970 (s)[c]	830 to 740 (s)[d]
P—O—C (arom)	1260 to 1160 (s)	994 to 855 (s)

[a]s = strong; w = weak.
[b]The increase in P═O stretching frequency of the ester, relative to the oxides, results from the electronegativity of the attached alkoxy groups.
[c]May be a doublet.
[d]May be absent.

APPENDIX E ABSORPTIONS FOR HETEROAROMATICS

TABLE E-1 γ-CH and Ring Bending (β-Ring) Bands of Pyridines[a]

Substitution	Number Adjacent H Atoms	γ-CH (cm^{-1})	β-Ring
2-	4	781 to 740	752 to 746
3-	3	810 to 789	715 to 712
4-	2	820 to 794	775 to 709

[a]The γ and β notations are explained in the text and in the book by Katritzky (1963).

TABLE E-2 Characteristic γ-CH or β-Ring Bands of Furans, Thiophenes, and Pyrroles

Ring	Position of Substitution	Phase	γ-CH or β-Ring Modes[a]			
			cm^{-1}	cm^{-1}	cm^{-1}	cm^{-1}
Furan	2-	$CHCl_3$	~925	~884	835 to 780	
	2-	Liquid	960 to 915	890 to 875		780 to 725
	2-	Solid	955 to 906	887 to 860	821 to 793	750 to 723
	3-	Liquid		885 to 870	741	
Thiophene	2-	$CHCl_3$	~925	~853	843 to 803	
	3-	Liquid				755
Pyrrole	2-Acyl	Solid			774 to 740	~755

[a]The γ and β notations are explained in the text and in the book by Katritzky (1963).