WebElements: the periodic table on the world-wide web

www.webelements.com

1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
hydrogen 1 **H** 1.0079																		helium 2 **He** 4.0026
lithium 3 **Li** 6.941	beryllium 4 **Be** 9.0122												boron 5 **B** 10.811	carbon 6 **C** 12.011	nitrogen 7 **N** 14.007	oxygen 8 **O** 15.999	fluorine 9 **F** 18.998	neon 10 **Ne** 20.180
sodium 11 **Na** 22.990	magnesium 12 **Mg** 24.305												aluminium 13 **Al** 26.982	silicon 14 **Si** 28.086	phosphorus 15 **P** 30.974	sulfur 16 **S** 32.065	chlorine 17 **Cl** 35.453	argon 18 **Ar** 39.948
potassium 19 **K** 39.098	calcium 20 **Ca** 40.078		scandium 21 **Sc** 44.956	titanium 22 **Ti** 47.867	vanadium 23 **V** 50.942	chromium 24 **Cr** 51.996	manganese 25 **Mn** 54.938	iron 26 **Fe** 55.845	cobalt 27 **Co** 58.933	nickel 28 **Ni** 58.693	copper 29 **Cu** 63.546	zinc 30 **Zn** 65.38	gallium 31 **Ga** 69.723	germanium 32 **Ge** 72.61	arsenic 33 **As** 74.922	selenium 34 **Se** 78.96	bromine 35 **Br** 79.904	krypton 36 **Kr** 83.80
rubidium 37 **Rb** 85.468	strontium 38 **Sr** 87.62		yttrium 39 **Y** 88.906	zirconium 40 **Zr** 91.224	niobium 41 **Nb** 92.906	molybdenum 42 **Mo** 95.96	technetium 43 **Tc** [98]	ruthenium 44 **Ru** 101.07	rhodium 45 **Rh** 102.91	palladium 46 **Pd** 106.42	silver 47 **Ag** 107.87	cadmium 48 **Cd** 112.41	indium 49 **In** 114.82	tin 50 **Sn** 118.71	antimony 51 **Sb** 121.76	tellurium 52 **Te** 127.60	iodine 53 **I** 126.90	xenon 54 **Xe** 131.29
caesium 55 **Cs** 132.91	barium 56 **Ba** 137.33	57-70 *	lutetium 71 **Lu** 174.97	hafnium 72 **Hf** 178.49	tantalum 73 **Ta** 180.95	tungsten 74 **W** 183.84	rhenium 75 **Re** 186.21	osmium 76 **Os** 190.23	iridium 77 **Ir** 192.22	platinum 78 **Pt** 195.08	gold 79 **Au** 196.97	mercury 80 **Hg** 200.59	thallium 81 **Tl** 204.38	lead 82 **Pb** 207.2	bismuth 83 **Bi** 208.98	polonium 84 **Po** [209]	astatine 85 **At** [210]	radon 86 **Rn** [222]
francium 87 **Fr** [223]	radium 88 **Ra** [226]	89-102 **	lawrencium 103 **Lr** [262]	rutherfordium 104 **Rf** [257]	dubnium 105 **Db** [268]	seaborgium 106 **Sg** [271]	bohrium 107 **Bh** [272]	hassium 108 **Hs** [270]	meitnerium 109 **Mt** [276]	darmstadtium 110 **Ds** [281]	roentgenium 111 **Rg** [280]	ununbium 112 **Uub** [285]	ununtrium 113 **Uut** [284]	ununquadium 114 **Uuq** [289]	ununpentium 115 **Uup** [288]	ununhexium 116 **Uuh** [293]	ununseptium 117 **Uus** –	ununoctium 118 **Uuo** [294]

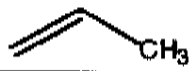
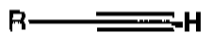
Key:

element name
atomic number
symbol
atomic weight (mean relative mass)

*lanthanoids	lanthanum 57 **La** 138.91	cerium 58 **Ce** 140.12	praseodymium 59 **Pr** 140.91	neodymium 60 **Nd** 144.24	promethium 61 **Pm** [145]	samarium 62 **Sm** 150.36	europium 63 **Eu** 151.96	gadolinium 64 **Gd** 157.25	terbium 65 **Tb** 158.93	dysprosium 66 **Dy** 162.50	holmium 67 **Ho** 164.93	erbium 68 **Er** 167.26	thulium 69 **Tm** 168.93	ytterbium 70 **Yb** 173.06
**actinoids	actinium 89 **Ac** [227]	thorium 90 **Th** 232.04	protactinium 91 **Pa** 231.04	uranium 92 **U** 238.03	neptunium 93 **Np** [237]	plutonium 94 **Pu** [244]	americium 95 **Am** [243]	curium 96 **Cm** [247]	berkelium 97 **Bk** [247]	californium 98 **Cf** [251]	einsteinium 99 **Es** [252]	fermium 100 **Fm** [257]	mendelevium 101 **Md** [258]	nobelium 102 **No** [259]

Symbols and names: the symbols and names of the elements, and their spellings are those recommended by the International Union of Pure and Applied Chemistry (IUPAC - http://www.iupac.org/). Names have yet to be proposed for the most recently discovered elements beyond 112 and so those used here are IUPAC's temporary systematic names. In the USA and some other countries, the spellings aluminum and cesium are normal while in the UK and elsewhere the common spelling is sulphur.
Group labels: the numeric system (1–18) used here is the current IUPAC convention.
Atomic weights (mean relative masses): Apart from the heaviest elements, these are the IUPAC 2007 values and given to 5 significant figures. Elements for which the atomic weight is given within square brackets have no stable nuclides and are represented by the element's longest lived isotope reported at the time of writing.

^{1}H NMR CHEMICAL SHIFT CHART*

Type of Proton	Formula	Chemical Shift
Reference peak	$Si(CH_3)_4$	0
Saturated primary	RCH_3	0.7-1.3
Saturated secondary	RCH_2R	1.2-1.4
Saturated tertiary	$RCHR_2$	1.4-1.7
Allylic primary		1.6-1.9
Methyl ketones	$RCOCH_3$	2.1-2.4
Aromatic methyl	$Ph\text{-}CH_3$	2.5-2.7
Alkyl chloride	$R\text{-}CH_2Cl$	3.0-4.0
Alkyl bromide	$R\text{-}CH_2Br$	2.5-4.0
Alkyl iodide	$R\text{-}CH_2I$	2.5-4.0
alkyl amine	RNH_2	Extremely variable (1-5)
Alcohol, ether	$R\text{-}CH_2O\text{-}R'$	3.3-4.0
Alkynyl		2.5-2.7
Vinylic		5.0-6.5
Aromatic	Ph-H	5.6-8.0
Aldehyde	RCOH	9.7-10.0
Carboxylic acid	RCOOH	11.0-12.0
Alcohol	ROH	Extremely variable (2.5-5.0)

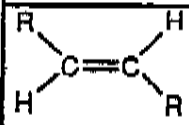
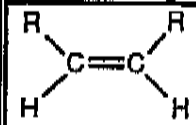
*data from McMurry, J. *Organic Chemistry*, Third edition, Brooks-Cole, California, 1992

please note: Ph = phenyl or an aromatic ring, the CO in the ketone and aldehyde is a carbonyl, ie, C=O

CHARACTERISTIC INFRARED FREQUENCIES*

cm^{-1}	Functional group	Comments
3600-3400	O-H stretching	3600-3500 cm^{-1} (sharp, often weak) from "free" or unassociated O-H; 3400-3200 cm^{-1} (broad) from H-bonded (associated) O-H. Carboxylic acids and β-dicarbonyl compounds have very strongly associated O-H with a very broad absorption (500 cm^{-1}) centered at 3000-2900 cm^{-1}.
3500-3200	N-H stretching	3300 cm^{-1} (sharp) from unassociated N-H; 3200 cm^{-1} (broad) from associated N-H. An NH_2 group usually appears as a doublet (ca. 50 cm^{-1} apart); N-H of a 2° amine often weak.
3300	C-H stretching terminal alkyne	Usually very sharp and strong in RC≡CH; look for confirmatory C≡C stretching at 2260-2100 cm^{-1}. Complete absence of absorption at 3300-3000 cm^{-1} indicates absence of H bonded C=C or C≡C; may be weak in large molecules.
3100-3000	C-H stretching alkene arene cyclopropane	Often weak in alkenes of high molecular weight. Symmetrical stretching of $=CH_2$ (2975 cm^{-1}) overlaps with alkane absorption.
3000-2800	C-H stretching alkane	Usually strong and multi-banded due to symmetrical and asymmetrical stretching as well as methyl, methylene, and methine differences. Absence of absorption indicates lack of sp^3 H-bearing carbon.
2820-2720	C-H stretching aldehyde	Often shows two bands from combination or overtone. Correlate with aldehyde C=O stretching at 1725 cm^{-1}.
2250-2225	C≡N stretching nitrile	2250 cm^{-1} unconjugated nitrile; 2225 cm^{-1} conjugated nitrile (special calibration usually needed to distinguish).
2260-2100	C≡C stretching	Moderate for terminal alkynes; very weak or absent if alkyne is nearly symmetrical.
2260-2100	C≡X=Y stretching	C=C=O stretching of ketenes (2150 cm^{-1}) and N=C=O stretching of isocyanates (2250 cm^{-1}) are very strong and characteristic.
1950	C=C=C stretching allene	Intensity depends on polarity of substituents. Other bands in the 2500-1900 cm^{-1} region can arise from S-H stretching (2600-2550 cm^{-1}, weak) and P-H stretching (2440-2350 cm^{-1}, medium) besides various overtone and combination absorptions.
1820 and 1760	C=O stretching of acid anhydride	Both bands are present and are altered by conjugation and ring size if cyclic. The bands are also present, but closer together, in diacyl perioxides.
1800	C=O stretching acyl chloride	Lowered to 1780-1760 cm^{-1} by conjugation.

cm^{-1}	Functional group	Comments
1770	C=O stretching γ-lactone	Lowered to ca. 1750 cm^{-1} by conjugation.
1745	C=O stretching 5-membered cyclic ketone	Lowered to ca. 1715 cm^{-1} by conjugation.
1735	C=O stretching ester	Lowered to ca. 1710 cm^{-1} by conjugation. Raised to ca. 1760 cm^{-1} by vinyl attached to oxygen.
1725	C=O stretching aldehyde	Lowered to ca. 1690 cm^{-1} by conjugation.
1715	C=O stretching ketone	Lowered to ca. 1680 cm^{-1} by conjugation. Raised by ca. 35 cm^{-1} per atom decrease in ring size below 6-membered ring.
1710	C=O stretching carboxylic acid (dimer)	Band appears near 1760 cm^{-1} in monomer (rarely observed). Shifts to 1610-1550 cm^{-1} in carboxylate anion (salts).
1690-1650	C=O stretching amide	Associated forms have C=O stretching ca. 30-40 cm^{-1} lower. NH_2 bending also makes a strong contribution to the 1650-1600 cm^{-1}.
1650-1600	C=C stretching alkene	Frequency is increased for exocyclic C=C with decreasing ring size; the opposite occurs for endoyclic C=C except for cyclopropene; absorption occurs at lower frequency in conjugated alkenes. Polar groups increase band intensity.
1640	C=N stretching	This band is usually weak (compared to C=O).
1600 and 1500 also 1580-and 1450	C=C stretching aromatic nuclei	Variable intensity; stronger when conjugated or electron donor groups are attached. Other systems also absorb in this region (e.g., NH_2 bending).
1600	$-NH_2$ bending	Useful to identify 1° amines and amides.
1540	-NH- bending	Useful to identify 2° amines and N-mono-substituted amides; may be weak.
1520 and 1350	$-NO_2$ asym. & sym. stretching	This pair of bands is usually quite intense.
1465	$-CH_2-$ bending	
1450 and 1380	$-CH_3$ bending	The lower frequency band is especially useful to detect methyl groups. Geminal methyl groups give rise to a doublet (1385 and 1365 cm^{-1}).
1410	$-CH_2CO-$	For a methylene group attached to a carbonyl group.
1325	-CH- bending	Usually weak and often unreliable.
1200	Ar-O	These strong bands are commonly assigned to C-O stretching. The position is shifted with unsaturation and branching, and over-lapping bending vibrations often make interpretation uncertain.
1150	-C-O-	
1100	-CH-O-	
1050	$-CH_2-O-$	
1050	RSOR' (sulfoxide)	Strong
1330 and 1140	RSO_2R' (sulfone)	Strong doublet (coupled oscillator)
1380 and 1170	RSO_3R'	Strong doublet (coupled oscillator)

cm^{-1}	Functional group	Comments
970	 C-H bending	Useful to distinguish E (trans) 1,2-disubstituted alkenes from Z (cis) isomers.
890	$R_2C=CH_2$ C-H bending	This strong band identifies a terminal methylene group. It is raised by 20-80 cm^{-1} if bonded to an electronegative atom or group.
815	$R_2C=CHR$ C-H bending	Moderately strong band to characterize a trisubstituted double bond.
730-675	 C-H bending	Usually broad and sometimes absured by solvent absorption (C-Cl).
750 and 690	monosubstituted phenyl C-H bending 5 adjacent H's	These are usually the strongest bands below 900 cm^{-1}. Electron withdrawing groups suc as $-NO_2$ increase the frequency by ca. 30 cm^{-1}. Chlorinated solvents obscure some of these bands.
750	*ortho*-disubst. phenyl C-H bending 4 adjacent H's	
780 and 700	*meta*-disubst. phenyl C-H bending 3 adjacent H's	
825	*para*-disubst. phenyl C-H bending 2 adjacent H's	

Infrared Regions Obscured by Solvents

Solvent	Region(s) Obscured
CCl_4	840-700 cm^{-1}
$CHCl_3$	3000 cm^{-1} 1200 cm^{-1} 840-700 cm^{-1}
CS_2	1600 - 1400 cm^{-1}

* Values mainly from dilute solutions in relatively nonpolar solvents. They often change with solvent and in liquid film or solid-state spectra.