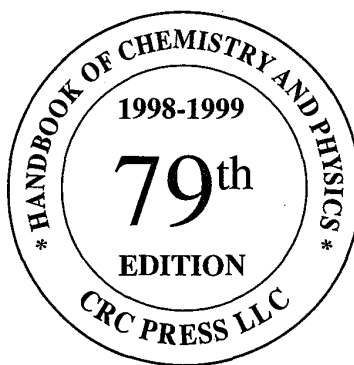


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STRENGTHS OF CHEMICAL BONDS*

J. A. Kerr

The strength of a chemical bond, $D^\circ(\text{R-X})$, often known as the bond dissociation energy, is defined as the standard enthalpy change of the reaction in which the bond is broken: $\text{RX} \rightarrow \text{R} + \text{X}$. It is given by the thermochemical equation, $D^\circ(\text{R-X}) = \Delta_f H^\circ(\text{R}) + \Delta_f H^\circ(\text{X}) - \Delta_f H^\circ(\text{RX})$. Some authors list bond strengths at a temperature of absolute zero but here the values at 298 K are given because more thermodynamic data are available for this temperature. Bond strengths or bond dissociation energies are not equal to, and may differ considerably from, mean bond energies determined solely from thermochemical data on atoms and molecules.

Table 1
BOND STRENGTHS IN DIATOMIC MOLECULES

These have usually been measured spectroscopically or by mass spectrometric analysis of hot gases effusing a Knudsen cell. Excellent accounts of these and other methods are given in (i) *Dissociation Energies and Spectra of Diatomic Molecules*, by A. G. Gaydon, 3rd. ed., Chapman & Hall, London, 1968 and (ii) "Mass Spectrometric Determination of Bond Energies of High-Temperature Molecules", K. A. Gingerich, *Chimia*, 26, 619, 1972. The errors quoted in the table are those given in the original paper or review article. The references have been chosen primarily as a key to the literature. It should not be assumed that the author referred to was responsible for the value quoted, as the reference may be to a review article.

Bond strengths reported at a temperature of absolute zero, D°_0 , have been converted to D°_{298} by the use of enthalpy functions taken mainly from the JANAF Thermochemical Tables, Third Edition, *J. Phys. Chem. Ref. Data*, 14, Suppl. 1, 1985, wherever possible. For most bonds, however, where these data are not available, the conversion has been made by the approximate relation:

$$D^\circ_{298} = D^\circ_0 + (3/2)RT$$

The list below does not include the increasing number of bond strengths of diatomic molecules now being calculated by *ab initio* methods. The Table has been arranged in an alphabetical order of the atoms.

Molecule	$D^\circ_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^\circ_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^\circ_{298}/\text{kJ mol}^{-1}$	Ref.
Ag-Ag	160.3 ± 3.4	296	Al-Au	325.9 ± 6.3	116	As-F	410	192
Ag-Al	183.7 ± 9.2	71	Al-Br	429 ± 6	176	As-Ga	209.6 ± 1.2	75
Ag-Au	202.9 ± 9.2	3	Al-Cl	511.3 ± 0.8	294	As-H	274.0 ± 2.9	26
Ag-Bi	193 ± 42	230	Al-Cu	227.1 ± 9.8	19	As-I	296.6 ± 28.0	308
Ag-Br	293 ± 29	112	Al-D	290.8	230	As-In	201	281
Ag-Cl	341.4	151	Al-F	663.6 ± 6.3	72	As-N	489 ± 2	292
Ag-Cu	174.1 ± 9.2	128	Al-H	284.9 ± 6.3	72	As-O	481 ± 8	245
Ag-D	226.8	192	Al-I	369.9 ± 2.1	250	As-P	433.5 ± 12.6	129
Ag-Dy	130 ± 19	190	Al-Kr	5.89 ± 0.81	39	As-S	379.5 ± 6.3	245
Ag-Eu	129.7 ± 12.6	58	Al-Li	175.7 ± 14.6	152	As-Sb	330.5 ± 5.4	87
Ag-F	354.4 ± 16.3	112	Al-N	297 ± 96	112	As-Se	96	272
Ag-Ga	180 ± 15	40	Al-Ni	225 ± 5	18	As-Tl	198.3 ± 14.6	284
Ag-Ge	174.5 ± 20.9	127	Al-O	511 ± 3	49,66	At-At	~80	81
Ag-H	215.1 ± 8	202	Al-P	216.7 ± 12.6	72	Au-Au	224.7 ± 1.5	31,234
Ag-Ho	123.4 ± 16.7	54	Al-Pd	254.4 ± 12.1	56	Au-B	367.8 ± 10.5	137
Ag-I	234 ± 29	112	Al-S	373.6 ± 7.9	352	Au-Ba	254.8 ± 10.0	127
Ag-In	166.5 ± 4.9	11	Al-Sb	216.3 ± 5.9	277	Au-Be	285 ± 8	112
Ag-Li	177.4 ± 6.3	260	Al-Se	337.6 ± 10.0	352	Au-Bi	297 ± 8.4	127
Ag-Mn	100 ± 21	230	Al-Si	229.3 ± 30.1	44	Au-Ca	243	127
Ag-Na	138.1 ± 8.4	275,282	Al-Te	267.8 ± 10.0	352	Au-Ce	339 ± 21	127
Ag-Nd	<209	206	Al-U	326 ± 29	115	Au-Cl	343 ± 9.6	112
Ag-O	220.1 ± 20.9	271	Al-Xe	7.43 ± 0.69	39	Au-Co	222 ± 17	127
Ag-S	217.1	329	Ar-Ar	4.73 ± 0.04	172	Au-Cr	213 ± 17	127
Ag-Se	202.5	329	Ar-He	3.89	230	Au-Cs	255 ± 3.3	37
Ag-Si	177.8 ± 10.0	303	Ar-Hg	6.15	230	Au-Cu	228.0 ± 5.0	31,127
Ag-Sn	136.0 ± 20.9	2	Ar-I	10.0	36	Au-D	318.4	192
Ag-Te	195.8	329	Ar-K	4.2	192	Au-Dy	259 ± 21	190
Al-Al	133 ± 6	110	As-As	382.0 ± 10.5	231	Au-Eu	241.0 ± 10.5	58
Al-Ar	5.34 ± 0.78	39	As-Cl	448	72	Au-Fe	187.0 ± 16.7	205
Al-As	202.9 ± 7.1	278,286	As-D	270.3	192	Au-Ga	234 ± 38	127

* Revised to December 1995.

Table 1
BOND STRENGTHS IN DIATOMIC MOLECULES (continued)

Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.
Au-Ge	274.1 ± 5.0	127	Ba-Br	362.8 ± 8.4	97,186,214	Br-Li	418.8 ± 4	341
Au-H	292.0 ± 8	202	Ba-Cl	436.0 ± 8.4	184,186	Br-Mg	≤ 327.2	192
Au-Ho	267.4 ± 16.7	54,234	Ba-D	≤ 193.7	192	Br-Mn	314.2 ± 9.6	112
Au-In	286.0 ± 5.7	11	Ba-F	587.0 ± 6.7	94,183	Br-N	276 ± 21	112
Au-La	336.4 ± 20.9	119	Ba-H	176 ± 14.6	112	Br-Na	367.4 ± 0.8	341,354
Au-Li	284.5 ± 6.7	260	Ba-I	320.8 ± 6.3	178	Br-Ni	360 ± 13	112
Au-Lu	332.2 ± 16.7	124	Ba-O	561.9 ± 13.4	271	Br-O	235.1 ± 0.4	72
Au-Mg	243 ± 42	230	Ba-Pd	221.8 ± 5.0	117	Br-Pb	247 ± 38	112
Au-Mn	185.4 ± 12.6	322	Ba-Rh	259.4 ± 25.1	117	Br-Rb	380.7 ± 4	341
Au-Na	215.1 ± 12.6	282	Ba-S	400.0 ± 18.8	62	Br-Sb	314 ± 59	112
Au-Nd	299.2 ± 20.9	119	Be-Be	59	32,79	Br-Sc	444 ± 63	230
Au-Ni	255 ± 21	127	Be-Br	381 ± 84	230	Br-Se	297 ± 84	230
Au-O	221.8 ± 20.9	271	Be-Cl	388.3 ± 9.2	101,181,358	Br-Si	367.8 ± 10.0	99
Au-Pb	130 ± 42	230	Be-D	203.05	192	Br-Sn	≥ 552	270
Au-Pd	155 ± 21	127	Be-F	577 ± 42	72,101	Br-Sr	333.0 ± 9.2	186
Au-Pr	310 ± 21	127	Be-H	200.0 ± 1.3	59	Br-Th	364	177
Au-Rb	243 ± 2.9	37	Be-O	434.7 ± 13.4	271	Br-Ti	439	230
Au-Rh	231.0 ± 29	58	Be-S	372 ± 59	112	Br-Tl	333.9 ± 1.7	25
Au-S	418 ± 25	123	Bi-Bi	200.4 ± 7.5	290,307	Br-U	377.4 ± 6.3	243
Au-Sc	280.3 ± 16.7	120	Bi-Br	267.4 ± 4.2	68	Br-V	439 ± 42	230
Au-Se	243.1	329	Bi-Cl	301 ± 4	70	Br-W	329.3	208
Au-Si	305.4 ± 5.9	131	Bi-D	283.7	249	Br-Y	485 ± 84	230
Au-Sn	254.8 ± 7.1	217	Bi-F	367 ± 13	375	Br-Zn	142 ± 29	230
Au-Sr	264 ± 42	230	Bi-Ga	159 ± 17	280	C-C	607 ± 21	72
Au-Tb	289.5 ± 33.5	144,234	Bi-H	≤ 283.3	249	C-Ce	444 ± 13	220
Au-Te	317.6	329	Bi-I	218.0 ± 4.6	69	C-Cl	397 ± 29	267
Au-U	318 ± 29	115	Bi-In	153.6 ± 1.7	304	C-D	341.4	192
Au-V	240.6 ± 12.1	165	Bi-Li	154.0 ± 5.0	262,288	C-F	552	182
Au-Y	307.1 ± 8.4	170	Bi-O	337.2 ± 12.6	271	C-Ge	460 ± 21	112
B-B	297 ± 21	72	Bi-P	280 ± 13	129	C-H	338.4 ± 1.2	192
B-Br	396	29	Bi-Pb	141.8 ± 14.6	307	C-Hf	540 ± 25	336
B-C	448 ± 29	230	Bi-S	315.5 ± 4.6	351	C-I	209 ± 21	112
B-Ce	305 ± 21	230	Bi-Sb	251 ± 4	228	C-Ir	632 ± 4	164
B-Cl	536	17	Bi-Se	280.3 ± 5.9	351	C-La	462 ± 20	274
B-D	341.0 ± 6.3	230	Bi-Sn	210.0 ± 8.4	127	C-Mo	481 ± 15.9	160
B-F	757	240	Bi-Te	232.2 ± 11.3	351	C-N	754.3 ± 10	38
B-H	340	287	Bi-Tl	121 ± 13	76	C-Nb	569 ± 13.0	160
B-I	220.5 ± 0.8	297	Br-Br	192.807	1	C-O	1076.5 ± 0.4	72
B-Ir	514.2 ± 17.2	357	Br-C	280 ± 21	112	C-Os	≥ 594	118
B-La	339 ± 63	230	Br-Ca	310.9 ± 9.2	302	C-P	513.4 ± 8	330
B-N	389 ± 21	72	Br-Cd	159 ± 96	112	C-Pt	598 ± 5.9	164,355
B-O	808.8 ± 20.9	271	Br-Cl	217.53 ± 0.29	50	C-Rh	580.0 ± 3.8	312
B-P	346.9 ± 16.7	139	Br-Co	331 ± 42	230	C-Ru	616.2 ± 10.5	313
B-Pd	329.3 ± 20.9	357	Br-Cr	328.0 ± 24.3	112	C-S	714.1 ± 1.2	63,333
B-Pt	477.8 ± 16.7	251	Br-Cs	389.1 ± 4	269,341	C-Sc	$\leq 444 \pm 21$	140
B-Rh	475.7 ± 20.9	357	Br-Cu	331 ± 25	112	C-Se	590.4 ± 5.9	323
B-Ru	446.9 ± 20.9	357	Br-D	370.74	192	C-Si	451.5	83,363
B-S	580.7 ± 9.2	350	Br-F	280 ± 12	197	C-Tc	565 ± 29	305
B-Sc	276 ± 63	230	Br-Fe	247 ± 96	112	C-Th	453 ± 17	159,336
B-Se	461.9 ± 14.6	350	Br-Ga	444 ± 17	72	C-Ti	423 ± 29	155,336
B-Si	288.3	363	Br-Ge	255 ± 29	112	C-U	454.8 ± 15.1	158,162
B-Te	354.4 ± 20.1	350	Br-H	366.35	192	C-V	427 ± 23.8	160
B-Th	297	132	Br-Hg	72.8 ± 4	72	C-Y	418 ± 14	318
B-Ti	276 ± 63	230	Br-I	179.1 ± 0.4	112,291	C-Zr	561 ± 25	336
B-U	322 ± 33	230	Br-In	414 ± 21	72	Ca-Ca	≤ 46	371,373
B-Y	293 ± 63	230	Br-K	379.9 ± 0.8	341,354	Ca-Cl	409 ± 9	252

Table 1
BOND STRENGTHS IN DIATOMIC MOLECULES (continued)

Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.
Ca-D	≤ 169.9	192	Cl-Rb	427.6 ± 8	342	Cu-Ho	142 ± 21	190
Ca-F	527 ± 21	94,180	Cl-S	277.0	209	Cu-I	197 ± 21	112
Ca-H	167.8	112	Cl-Sb	360 ± 50	112	Cu-In	187.4 ± 7.9	11
Ca-I	284.7 ± 8.4	178	Cl-Sc	331	362	Cu-Li	192.9 ± 8.8	260
Ca-Li	84.9 ± 8.4	371	Cl-Se	322	230	Cu-Mn	158.6 ± 17	207
Ca-O	402.1 ± 16.7	271	Cl-Si	406	361	Cu-Na	176.1 ± 16.7	283
Ca-S	337.6 ± 18.8	62,192	Cl-Sm	$\geq 423 \pm 13$	374	Cu-Ni	205.9 ± 17	207
Cd-Cd	7.36	235	Cl-Sn	414 ± 17	230	Cu-O	269.0 ± 20.9	271
Cd-Cl	208.4	192	Cl-Sr	406 ± 13	184,186	Cu-S	276	329
Cd-F	305 ± 21	28	Cl-Ta	544	20	Cu-Se	251	329
Cd-H	69.0 ± 0.4	112	Cl-Th	489	244	Cu-Si	221.3 ± 6.3	303
Cd-I	97.23	200	Cl-Ti	494	230	Cu-Sn	169.5 ± 6.7	2,221
Cd-In	138	230	Cl-Tl	372.8 ± 2.1	25	Cu-Tb	193 ± 19	190
Cd-O	235.6 ± 83.7	149,271	Cl-U	452 ± 8	242	Cu-Te	278.7	1
Cd-S	208.4 ± 20.9	149	Cl-V	477 ± 63	230	D-D	443.533	192
Cd-Se	127.6 ± 25.1	149	Cl-W	423 ± 42	230	D-F	576.6	192
Cd-Te	100.0 ± 15.1	149	Cl-Xe	6.7	192	D-Ga	< 272.8	237
Ce-Ce	245.2	119	Cl-Y	527 ± 84	230	D-Ge	≤ 322	192
Ce-F	582 ± 42	230	Cl-Yb	~ 322	107	D-H	439.433	192
Ce-Ir	586	141	Cl-Zn	228.9 ± 19.7	65	D-Hg	42.05	192
Ce-N	519 ± 21	138	Cm-O	736	321	D-In	246.0	192
Ce-O	795 ± 8	88	Co-Co	167 ± 25	203	D-Li	240.1892 ± 0.0046	194,339
Ce-Os	506 ± 33	118	Co-Cu	167 ± 17	127	D-Mg	135.1	192
Ce-Pd	322.2	55	Co-F	435 ± 63	230	D-Ni	≤ 302.9	192
Ce-Pt	556	141	Co-Ge	234 ± 21	127	D-Pt	≤ 350.2	192
Ce-Rh	548	141	Co-H	226 ± 42	347	D-S	351	192
Ce-Ru	531 ± 25	118	Co-I	285 ± 21	230	D-Si	302.5	192
Ce-S	569	21	Co-O	384.5 ± 13.4	271	D-Sr	≥ 275.7	192
Ce-Se	494.5 ± 14.6	255	Co-S	331	329	D-Zn	88.7	192
Ce-Te	189.4 ± 12.8	236	Co-Si	276 ± 17	356	Dy-F	531	381
Cl-Cl	242.580 ± 0.004	192	Cr-Cr	142.9 ± 5.4	188	Dy-O	607 ± 17	88
Cl-Co	389	238	Cr-Cu	155 ± 21	207	Dy-S	414 ± 42	230
Cl-Cr	366.1 ± 24.3	112	Cr-F	444.8 ± 19.7	211	Dy-Se	322 ± 42	230
Cl-Cs	448 ± 8	269,342	Cr-Ge	154 ± 7	189	Dy-Te	234 ± 42	230
Cl-Cu	382.8 ± 4.6	154	Cr-H	190.3 ± 7.0	46	Er-F	565 ± 17	381
Cl-D	436.47	192	Cr-I	287.0 ± 24.3	112	Er-O	615 ± 13	88
Cl-Eu	~ 326	107	Cr-N	377.8 ± 18.8	144,334	Er-S	418 ± 42	230
Cl-F	256.23	192,264	Cr-O	429.3 ± 29.3	271	Er-Se	326 ± 42	230
Cl-Fe	~ 351	112	Cr-Pb	105 ± 2	189	Er-Te	238 ± 42	230
Cl-Ga	481 ± 13	72	Cr-S	331	85	Eu-Eu	33.5 ± 17	58
Cl-Ge	~ 431	192	Cr-Sn	141 ± 3	189	Eu-F	544	226
Cl-H	431.62	192	Cs-Cs	43.919 ± 0.010	368	Eu-Li	66.9 ± 2.9	259
Cl-Hg	100 ± 8	112	Cs-F	519 ± 8	269	Eu-O	479 ± 10	88
Cl-I	211.3 ± 0.4	112	Cs-H	175.364	376	Eu-Rh	233.9 ± 33	58
Cl-In	439 ± 8	72	Cs-Hg	8	192	Eu-S	362.3 ± 13.0	255,327
Cl-K	433.0 ± 8	342	Cs-I	337.2 ± 2.1	269,340	Eu-Se	301 ± 14.6	22,171,255
Cl-Li	469 ± 13	72	Cs-Na	63.2 ± 1.3	78	Eu-Te	243 ± 14.6	22,255
Cl-Mg	327.6 ± 2.1	98,184,358	Cs-O	295.8 ± 62.8	271	F-F	158.78	192
Cl-Mn	360.7 ± 9.6	112	Cs-Rb	49.57 ± 0.01	167	F-Ga	577 ± 14.6	254
Cl-N	333.9 ± 9.6	47	Cu-Cu	176.52 ± 2.38	127,306	F-Gd	590.4 ± 27.2	378
Cl-Na	412.1 ± 8	342	Cu-D	270.3	192	F-Ge	485 ± 21	91
Cl-Ni	372 ± 21	112	Cu-Dy	142 ± 21	190	F-H	569.87 ± 0.06	377
Cl-O	269.1	192,301	Cu-F	413.4 ± 13	92	F-Hf	650 ± 15	14
Cl-P	289 ± 42	230	Cu-Ga	215.9 ± 15.1	40	F-Hg	~ 180	192
Cl-Pb	301 ± 29	112	Cu-Ge	208.8 ± 21	257	F-Ho	540	381
Cl-Ra	343 ± 75	112	Cu-H	277.8	202,300	F-I	≤ 271.5	6,30,51,67

STRENGTHS OF CHEMICAL BONDS (continued)

Table 1
BOND STRENGTHS IN DIATOMIC MOLECULES (continued)

Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.
F-In	506 ± 14.6	254	Gd-O	719 ± 10	88	Hg-O	220.9 ± 33.1	149
F-K	497.5 ± 2.5	15	Gd-S	526.8 ± 10.5	109,325	Hg-Rb	8.4	192
F-La	598 ± 42	230	Gd-Se	431 ± 14.6	22	Hg-S	217.1 ± 22.2	149
F-Li	577 ± 21	72	Gd-Te	343 ± 14.6	22	Hg-Se	144.3 ± 30.1	149
F-Lu	333.5	195	Ge-Ge	263.6 ± 7.1	222	Hg-Te	≤142	230
F-Mg	461.9 ± 5.0	94,183	Ge-H	≤321.7	227	Hg-Tl	4	174
F-Mn	423.4 ± 14.6	212	Ge-Ni	290.3 ± 10.9	315	Ho-Ho	84 ± 17	54
F-Mo	464.8	185	Ge-O	659.4 ± 12.6	271	Ho-O	611 ± 17	88
F-N	343	192	Ge-Pd	254.7 ± 10.5	314	Ho-S	428.4 ± 14.6	325
F-Na	519	192	Ge-S	551.0 ± 2.5	80,86	Ho-Se	335 ± 17	22
F-Nd	545.2 ± 12.6	379	Ge-Sc	271.0 ± 11	218	Ho-Te	259 ± 17	22
F-Ni	430 ± 20	77	Ge-Se	489 ± 4	266	I-I	151.088	192,348
F-O	222 ± 17	52	Ge-Si	301 ± 21	112	I-In	331	360
F-P	439 ± 96	112	Ge-Te	456 ± 13	106	I-K	325.1 ± 0.8	340,354
F-Pb	356 ± 8	383	Ge-Y	279.8 ± 11.4	219	I-Li	345.2 ± 4.2	340
F-Pm	540 ± 42	230	H-H	435.990	192	I-Mg	~285	23
F-Pr	582 ± 46	230	H-Hg	39.844	192	I-Mn	282.8 ± 9.6	112
F-Pu	538.5 ± 29	213	H-I	298.407	192	I-N	159 ± 17	230
F-Rb	494 ± 21	72	H-In	243.1	192	I-Na	304.2 ± 2.1	340,354
F-Ru	402	175	H-K	174.576	193,376	I-Ni	293 ± 21	112
F-S	342.7 ± 5.0	27,187,215	H-Li	238.049 ± 0.004	367	I-O	249.0 ± 1.3	301
F-Sb	439 ± 96	112	H-Mg	126.4 ± 2.9	12,13,93	I-Pb	193 ± 4	320
F-Sc	589.1 ± 13	380	H-Mn	234 ± 29	112	I-Rb	318.8 ± 2.1	340
F-Se	339 ± 42	230	H-N	≤339	192	I-Si	293	192
F-Si	552.7 ± 2.1	102	H-Na	185.69 ± 0.25	258,298	I-Sn	234 ± 42	230
F-Sm	565	226	H-Ni	252.3 ± 8	202	I-Sr	269.9 ± 5.9	223
F-Sn	466.5 ± 13	383	H-O	427.6	192	I-Te	192 ± 42	230
F-Sr	541.8 ± 6.7	94,183	H-P	297	192	I-Ti	310 ± 42	230
F-Ta	573 ± 13	239	H-Pb	≤157	192	I-Tl	272 ± 8	23
F-Tb	561 ± 42	230	H-Pd	234 ± 25	347	I-Zn	108.29	200
F-Th	652	246	H-Pt	≤335	192	I-Zr	305	225
F-Ti	569 ± 33	382	H-Rb	167 ± 21	112	In-In	100 ± 8	230
F-Tl	445.2 ± 19.2	25	H-Rh	247 ± 21	347	In-Li	92.5 ± 14.6	152
F-Tm	510	226	H-Ru	234 ± 21	347	In-O	<320.1 ± 41.8	271
F-U	659.0 ± 10.5	148,241	H-S	344.3 ± 12.1	198	In-P	197.9 ± 8.4	278
F-V	590 ± 63	230	H-Sc	~180	309	In-S	289 ± 17	61
F-W	548 ± 63	230	H-Se	314.47 ± 0.96	114	In-Sb	151.9 ± 10.5	73
F-Xe	15.77	299,346	H-Si	≤299.2	192	In-Se	247 ± 17	61
F-Y	605.0 ± 20.9	380	H-Sn	264 ± 17	112	In-Te	218 ± 17	61
F-Yb	≥521.3 ± 9.6	16,107,374	H-Sr	163 ± 8	112	Ir-La	577 ± 13	169
F-Zn	368 ± 63	230	H-Te	268 ± 2.1	111	Ir-O	414.6 ± 42.3	271
F-Zr	616 ± 15	14	H-Ti	204.6 ± 8.8	45	Ir-Si	462.8 ± 20.9	357
Fe-Fe	75 ± 17	310	H-Tl	188 ± 8	112	Ir-Th	573	125
Fe-Ge	210.9 ± 29	204	H-V	208.7 ± 7.0	46	Ir-Ti	422 ± 13	273
Fe-H	180 ± 25	347	H-Yb	159 ± 38	112	Ir-Y	456.1 ± 16.7	170
Fe-O	390.4 ± 17.2	271	H-Zn	85.8 ± 2.1	112	K-K	54.63 ± 0.02	5,248
Fe-S	322	85	He-He	3.8	192	K-Kr	4.6	192
Fe-Si	297 ± 25	356	He-Hg	6.61	230	K-Li	82.0 ± 4.2	96,385
Ga-Ga	112.1 ± 7	317	Hf-C	548 ± 63	230	K-Na	65.994 ± 0.008	33,385
Ga-H	<274.1	237	Hf-N	536 ± 29	144,229	K-O	277.8 ± 20.9	271
Ga-I	339 ± 9.6	112	Hf-O	801.7 ± 13.4	271	K-Xe	5.0	192
Ga-Li	133.1 ± 14.6	152	Hg-Hg		190,191	Kr-Kr	5.23	42,192
Ga-O	353.5 ± 41.8	271	Hg-I	34.69 ± 0.96	365	Kr-O	<8	230
Ga-P	229.7 ± 12.6	122	Hg-K	8.24 ± 0.21	230	Kr-Xe	5.505 ± 0.002	7
Ga-Sb	192.0 ± 12.6	279	Hg-Li	13.8	192	La-La	247 ± 21	362
Ga-Te	251 ± 25	353	Hg-Na	9.2	192,386	La-N	519 ± 42	230

Table 1
BOND STRENGTHS IN DIATOMIC MOLECULES (continued)

Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.
La-O	799 ± 4	88	Nd-O	703 ± 13	88	P-Th	550.2 ± 42	127
La-Pt	502 ± 21	256	Nd-S	471.5	22	P-Tl	209 ± 13	277
La-Rh	527 ± 17	57	Nd-Se	385 ± 17	22,147,255	P-U	297 ± 21	230
La-S	573.2 ± 1.7	199,338	Nd-Te	305 ± 17	22	P-W	305 ± 4	142
La-Se	477 ± 17	22,255	Ne-Ne	3.93	344	Pb-Pb	86.6 ± 0.8	130,288
La-Te	381 ± 17	22,145	Ni-Ni	203.26 ± 0.96	253	Pb-S	346.0 ± 1.7	351
La-Y	202.1	362	Ni-O	382.0 ± 16.7	271	Pb-Sb	161.5 ± 10.5	384
Li-Li	110.21 ± 4	359,372	Ni-Pt	273.7 ± 0.3	345	Pb-Se	302.9 ± 4	351
Li-Mg	67.4 ± 6.3	370	Ni-S	344.3	85	Pb-Te	251 ± 13	351
Li-Na	87.181 ± 0.001	95,104	Ni-Si	318 ± 17	356	Pd-Pd	100 ± 15	311
Li-O	333.5 ± 8.4	271	Ni-V	206.3 ± 0.2	332	Pd-Si	261 ± 12	316
Li-Pb	78.7 ± 7.9	262	Np-O	718.4 ± 41.8	271	Pd-Y	238 ± 17	295
Li-S	312.5 ± 7.5	216	O-O	498.36 ± 0.17	35,192	Pm-S	423 ± 63	230
Li-Sb	172.8 ± 10.0	263	O-Os	575	179	Pm-Se	339 ± 63	230
Li-Sm	49.0 ± 4.2	259	O-P	599.1 ± 12.6	271	Pm-Te	255 ± 63	230
Li-Tm	69.0 ± 3.3	259	O-Pa	788.3 ± 17.2	224	Po-Po	187.0	192
Li-Yb	37.2 ± 2.9	259	O-Pb	382.0 ± 12.6	271	Pr-S	492.5 ± 4.6	105
Lu-Lu	142 ± 33	230	O-Pd	380.7 ± 83.7	271	Pr-Se	446.4 ± 23.0	146,255
Lu-O	678 ± 8	88	O-Pm	674 ± 63	230	Pr-Te	326 ± 42	230
Lu-Pt	402 ± 33	133	O-Pr	753 ± 13	88	Pt-Pt	357.3 ± 15.1	163
Lu-S	507.1 ± 14.6	108,325	O-Pt	391.6 ± 41.8	271	Pt-Si	501.2 ± 18.0	357
Lu-Se	418 ± 17	22	O-Pu	715.9 ± 33.9	271	Pt-Th	552	125
Lu-Te	326 ± 17	22	O-Rb	255 ± 84	34	Pt-Ti	397 ± 13	166
Mg-Mg	8.552 ± 0.004	247,371	O-Re	626.8 ± 83.7	271	Pt-Y	474.0 ± 12.1	163
Mg-O	363.2 ± 12.6	271	O-Rh	405.0 ± 41.8	271	Rb-Rb	48.898 ± 0.005	4
Mg-S	234	62	O-Ru	528.4 ± 41.8	271	Rh-Rh	285.3 ± 20.9	53,285
Mn-Mn	25.9	206	O-S	521.7 ± 4.2	271	Rh-Sc	443.9 ± 10.5	168
Mn-O	402.9 ± 41.8	210,271	O-Sb	434.3 ± 41.8	271	Rh-Si	395.0 ± 18.0	357
Mn-S	301 ± 17	369	O-Sc	681.6 ± 11.3	271	Rh-Th	515 ± 21	121
Mn-Se	239.3 ± 9.2	331	O-Se	464.8 ± 21.3	271,324	Rh-Ti	390.8 ± 14.6	53
Mo-Mo	406 ± 21	161	O-Si	799.6 ± 13.4	271	Rh-U	519 ± 17	121
Mo-Nb	456 ± 25	156	O-Sm	565 ± 13	88	Rh-V	364 ± 29	127
Mo-O	560.2 ± 20.9	271	O-Sn	531.8 ± 12.6	271	Rh-Y	445.2 ± 10.5	168
N-N	945.33 ± 0.59	192	O-Sr	425.5 ± 16.7	271	Ru-Si	397.1 ± 20.9	357
N-O	630.57 ± 0.13	192	O-Ta	799.1 ± 12.6	271	Ru-Th	591.6 ± 42	126
N-P	617.1 ± 20.9	64,143	O-Tb	711 ± 13	88	Ru-V	414 ± 29	127
N-Pu	473 ± 63	230	O-Te	376.1 ± 20.9	271	S-S	425.30	192
N-S	464 ± 21	230	O-Th	878.6 ± 12.1	271	S-Sb	378.7	103
N-Sb	301 ± 50	112	O-Ti	672.4 ± 9.2	271	S-Sc	477 ± 13	338,349
N-Sc	469 ± 84	230	O-Tm	502 ± 13	88	S-Se	371.1 ± 6.7	82
N-Se	370 ± 11	333	O-U	759.4 ± 13.4	271	S-Si	623	192
N-Si	470 ± 15	293	O-V	626.8 ± 18.8	10,271	S-Sm	389	105
N-Ta	611 ± 84	230	O-W	672.0 ± 41.8	271	S-Sn	464 ± 3.3	80
N-Th	577.4 ± 33.1	136,144	O-Xe	36.4	230	S-Sr	339	41
N-Ti	476.1 ± 33.1	144,335	O-Y	719.6 ± 11.3	196,271	S-Tb	515 ± 42	230
N-U	531.4 ± 2.1	134	O-Yb	397 ± 17	88	S-Te	339 ± 21	80
N-V	477.4 ± 17.2	100,144	O-Zn	159 ± 4	48	S-Ti	418 ± 3	89,276
N-Xe	23.0	173	O-Zr	776.1 ± 13.4	271	S-Tm	368 ± 42	230
N-Y	481 ± 63	230	P-P	489.5 ± 10.5	143	S-U	522.6 ± 9.6	338
N-Zr	564.8 ± 25.1	135,144	P-Pt	≤416.7 ± 17	328	S-V	450	90,192
Na-Na	73.60 ± 0.25	364	P-Rh	353.1 ± 17	328	S-Y	528.4 ± 10.5	337
Na-O	256.1 ± 16.7	271	P-S	444 ± 8	84	S-Yb	167	230
Na-Rb	63.25	366	P-Sb	356.9	233	S-Zn	205 ± 13	74,149
Nb-Nb	510 ± 10.0	157	P-Se	363.6 ± 10.0	84	S-Zr	575.3 ± 16.7	338
Nb-O	771.5 ± 25.1	271	P-Si	363.6	326	Sb-Sb	299.2 ± 6.3	73,232
Nd-Nd	<163	230	P-Te	297.9 ± 10.0	84	Sb-Te	277.4 ± 3.8	289,343

Table 1
BOND STRENGTHS IN DIATOMIC MOLECULES (continued)

Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.	Molecule	$D^{\circ}_{298}/\text{kJ mol}^{-1}$	Ref.
Sb-Tl	126.8 ± 10.5	9,277	Se-V	347 ± 21	230	Te-Tm	276 ± 42	230
Sc-Sc	162.8 ± 21	128	Se-Y	435 ± 13	230	Te-Y	339 ± 13	230
Sc-Se	385 ± 17	230	Se-Zn	170.7 ± 25.9	74,149	Te-Zn	117.6 ± 18.0	149
Sc-Si	228.7 ± 14	218	Si-Si	326.8 ± 10.0	44	Th-Th	≤ 289	132
Sc-Te	289 ± 17	230	Si-Te	452 ± 8	192,265	Ti-Ti	141.4 ± 21	201
Se-Se	332.6 ± 0.4	82,351	Si-Y	258.8 ± 17.3	219	Tl-Tl	64.4 ± 17	8
Se-Si	548	192	Sm-Te	272.4 ± 14.6	255	U-U	222 ± 21	230
Se-Sm	331.0 ± 14.6	255	Sn-Sn	187.1 ± 0.3	268	V-V	269.2 ± 0.2	332
Se-Sn	401.2 ± 5.9	60	Sn-Te	359.8	192	Xe-Xe	6.53 ± 0.29	43
Se-Sr	-285	24	Sr-Sr	15.5 ± 0.4	113	Y-Y	159 ± 21	230
Se-Tb	423 ± 42	230	Tb-Tb	131.4 ± 25.1	234	Yb-Yb	20.5 ± 17	153
Se-Te	291.6 ± 4	80,82,150	Tb-Te	339 ± 42	230	Zn-Zn	29	319
Se-Ti	381 ± 42	230	Te-Te	259.8 ± 5.0	261			
Se-Tm	276 ± 42	230	Te-Ti	289 ± 17	230			

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Table 1
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