PERIODIC TABLE OF THE ELEMENTS

Table of Selected Radioactive Isotopes

₀n	1	(10.3 min) β^-	₄₂Mo	67	(61.88 h) β^-	₅₁Sb	124	(60.20 d) β^+	₇₄W	181	(140 d) EC	₉₁Pa	231	(3.28x10⁴ y) α
₁H	3	(12.26 y) β^-	₄₃Tc	65	(244.1 d) β^+, EC		125	(2.7 y) β^-		185	(75.1 d) β^-	₉₂U	233	(1.59x10⁵ y) α
₄Be	7	(53.3 d) EC	₄₄Ru	67	(78.2 h) EC	₅₂Te	121	m (154 d) IT		188	(69 d) β^-		234	(2.44x10⁵ y) α
	10	(~4x10⁶ y) β^-		72	(14.10 h) β^-		123	m (119.7 d) IT	₇₅Re	187	(5x10¹⁰ y) β^-		235	(7.04x10⁸ y) α
₆C	11	(20.40 min) β^+	₄₅Rh	68	(275 d) EC		127	m (109 d) IT	₇₆Os	194	(6.0 y) β^-		236	(2.34x10⁷ y) α
	14	(5730 y) β^-	₄₆Pd	73	(80.3 d) EC	₅₃I	129	(1.6x10⁷ y) β^-	₇₇Ir	192	(74.2 d) β^-, β^+, EC		238	(4.47x10⁹ y) α
₉F	18	(~109.8 min) β^+		74	(17.9 d) β^-, β^+, EC		131	(8.040 d) β^-	₇₉Au	195	(183 d) EC	₉₃Np	236	(1.1x10⁵ y) EC, β^-
₁₁Na	22	(2.602 y) β^+, EC	₄₇Ag	75	(118.5 d) β^-	₅₄Xe	133	(5.25 d) β^-		196	(6.18 d) β^+, EC, β^-		237	(2.14x10⁶ y) α
	24	(15.02 h) β^-		79	(6.5x10⁴ y) β^-		135	(9.10 h) β^-		198	(2.696 d) β^-		239	(2.346 d) β^-
₁₂Mg	28	(20.9 h) β^-	₄₈Cd	82	(35.34 h) β^-	₅₅Cs	134	(2.06 y) β^-		199	(3.15 d) β^-	₉₄Pu	238	(87.75 y) α
₁₃Al	26	(7.2x10⁵ y) β^+, EC	₄₉In	81	(2.1x10⁵ y) EC		135	(2.9x10⁶ y) β^-	₈₀Hg	203	(46.8 d) β^-		239	(2.41x10⁴ y) α
₁₅P	32	(14.26 d) β^-		85	(10.72 y) β^-		137	(30.17 y) β^-	₈₁Tl	204	(3.77 y) β^-		240	(6.54x10³ y) α
₁₆S	35	(87.2 d) β^-	₃₇Rb	86	(18.7 d) β^-	₅₆Ba	140	(12.8 d) β^-	₈₂Pb	202	(3x10⁵ y) EC		242	(3.8x10⁵ y) α
₁₇Cl	36	(3.01x10⁵ y) β^-		87	(4.8x10¹⁰ y) β^-	₅₇La	137	(6x10⁴ y) EC		205	(3x10⁷ y) EC		244	(8.3x10⁷ y) α
	38	(37.2 min) β^-	₃₈Sr	90	(28.8 y) β^-		140	(40.3 h) β^-		210	(22.3 y) β^-, α	₉₅Am	241	(432 y) α
₁₈Ar	37	(35.02 d) EC	₃₉Y	88	(106.6 d) β^+, EC	₅₈Ce	144	(284 d) β^-	₈₃Bi	207	(38 y) EC		243	(7.37x10³ y) α
	39	(265 y) β^-	₄₀Zr	93	(1.5x10⁶ y) β^-	₅₉Pr	142	(19.1 h) β^-		208	(3.7x10⁵ y) EC	₉₆Cm	242	(163.2 d) α
₁₉K	40	(1.26x10⁹ y) EC		95	(64.0 d) β^-		144	(17.1 d) β^-		210	(5.01 d) β^-, α		244	(18.12 y) α
	42	(12.36 h) β^-	₄₁Nb	94	(2.0x10⁴ y) β^-	₆₀Nd	145	(8 y) EC		210	m (3x10⁶ y) α		247	(1.55x10⁷ y) α
₂₀Ca	45	(165 d) β^-		95	(35.15 d) β^-		147	(2.62 y) β^-	₈₄Po	208	(2.90 y) α		248	(3.5x10⁵ y) α, SF
₂₁Sc	46	(83.90 d) β^-	₄₂Mo	99	(66.02 h) β^-	₆₁Pm	146	(7x10⁷ y) α		209	(102 y) α	₉₇Bk	247	(1.4x10³ y) α
₂₂Ti	51	(27.70 d) EC	₄₃Tc	97	(2.6x10⁶ y) EC		151	(93 y) β^-		210	(138.38 d) α	₉₈Cf	249	(351 y) α
₂₃V	48	(16.0 d) EC		98	(4.2x10⁶ y) β^-	₆₂Sm	145	(340 d) EC	₈₅At	209	(5.4 h) EC, α		251	(900 y) α
₂₄Cr	51	(27.70 d) EC		99	(2.13x10⁵ y) β^-		151	(90 y) EC		210	(8.1 h) EC	₉₉Es	252	(472 d) α
₂₅Mn	53	(3x10⁶ y) EC	₄₄Ru	103	(39.35 d) β^-	₆₃Eu	152	(13 y) β^+, EC, β^-		211	(7.21 h) EC, α		253	(20.47 d) α
	54	(313.0 d) EC	₄₅Rh	106	(367 d) β^-		154	(8.5 y) β^-	₈₆Rn	222	(3.824 d) α		254	(276 d) α
₂₆Fe	59	(44.6 d) β^-	₄₆Pd	103	(17.0 d) EC		155	(1.2x10⁷ y) EC	₈₇Fr	212	(19.3 min) EC, α	₁₀₀Fm	255	(20.1 h) α
₂₇Co	56	(78.8d) β^+, EC		107	(7x10⁶ y) β^-	₆₄Gd	148	(74.6 y) α		223	(21.8 min) β^-		257	(100.5 d) α
	57	(270 d) EC	₄₇Ag	108	(127 y) EC		150	(1.79x10⁶ y) α	₈₈Ra	226	(1.60x10³ y) α	₁₀₁Md	258	(55 d) α
	58	(71.3 d) β^+, EC		110	(252 d) β^-		151	(120 y) EC	₈₉Ac	227	(21.77 y) β^-	₁₀₂No	259	(58 min) α
	60	(3.272 y) β^-		111	(7.45 d) β^-		152	(1.08x10¹⁴ y) α	₉₀Th	228	(1.913 y) α	₁₀₃Lr	260	(3.0 min) α
₂₈Ni	56	(6.10 d) β^+, EC	₄₈Cd	109	(453 d) EC		153	(240 d) β^-		230	(7.7x10⁴ y) α		261	(65 y) α
	59	(3x10⁵ y) EC	₄₉In	114	(49.51 d) IT	₆₅Tb	157	(71 y) EC		232	(1.40x10¹⁰ y) α		262	(40 s) α
	63	(92 y) β^-	₅₀Sn	121	(76 y) β^-		158	(150 y) EC					263	(0.9 s) α
₂₉Cu	64	(12.70 h) β^-, β^+, EC				₇₀Tm	167	(9.24 d) EC						

Selected Radioactive Isotopes

Naturally occurring radioactive isotopes are designated by a mass number in blue (although some are also manufactured). Letter *m* indicates an isomer of another isotope of the same mass number. Half-lives follow in parentheses, where s, min, h, d, and y stand respectively for seconds, minutes, hours, days, and years. The table includes mainly the longer-lived radioactive isotopes; many others have been prepared. Isotopes known to be radioactive but with half-lives exceeding 10^{18} y have not been included. Symbols describing the principal mode (or modes) of decay are as follows (these processes are generally accompanied by gamma radiation):

- α alpha particle emission
- β^- beta particle (electron) emission
- β^+ position emission
- EC orbital electron capture
- IT isomeric transition from upper to lower isomeric state
- SF spontaneous fission

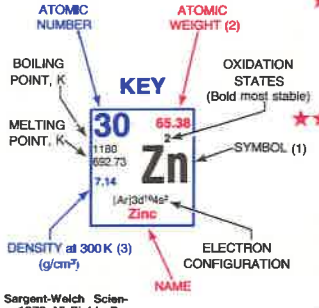
GROUP IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA					IB	IIB	IIIB	IVB	VB	VIB	VIIB	VIII
1 1.0079 1 20.268 14.025 0.0899* 1s¹ **H** Hydrogen																			2 4.00260 4.215 0.95 (at 20.000) 0.1787* 1s² **He** Helium
3 6.941 1 1615 453.7 0.53 1s²2s¹ **Li** Lithium	4 9.01218 2 2745 1560 1.85 1s²2s² **Be** Beryllium													5 10.81 3 4275 2300 2.34 1s²2s²p¹ **B** Boron	6 12.011 ±4,2 4470* 4100* 2.62 1s²2s²p² **C** Carbon	7 14.0067 ±3,5,4,2 77.35 63.14 1.251* 1s²2s²p³ **N** Nitrogen	8 15.9994 −2 90.18 50.35 1.429* 1s²2s²p⁴ **O** Oxygen	9 18.998403 −1 84.95 53.48 1.696* 1s²2s²p⁵ **F** Fluorine	10 20.179 27.096 24.553 0.901* 1s²2s²p⁶ **Ne** Neon
11 22.98977 1 1156 371.0 0.97 [Ne]3s¹ **Na** Sodium	12 24.305 2 1363 922 1.74 [Ne]3s² **Mg** Magnesium													13 26.98154 3 2793 933.25 2.70 [Ne]3s²p¹ **Al** Aluminum	14 28.0855 ±4 3540 1685 2.33 [Ne]3s²p² **Si** Silicon	15 30.97376 ±3,5,4 550 317.30 1.82 [Ne]3s²p³ **P** Phosphorus	16 32.06 ±2,4,6 717.75 388.36 2.07 [Ne]3s²p⁴ **S** Sulfur	17 35.453 ±1,3,5,7 239.1 172.16 3.17* [Ne]3s²p⁵ **Cl** Chlorine	18 39.948 87.30 83.81 1.784* [Ne]3s²p⁶ **Ar** Argon
19 39.0983 1 1032 336.35 0.86 [Ar] 4s¹ **K** Potassium	20 40.08 2 1757 1112 1.55 [Ar]4s² **Ca** Calcium	21 44.9559 3 3104 1812 3.0 [Ar]3d¹4s² **Sc** Scandium	22 47.90 4,3 3562 1943 4.50 [Ar]3d²4s² **Ti** Titanium	23 50.9415 5,4,3,2 3682 2175 5.8 [Ar]3d³4s² **V** Vanadium	24 51.996 6,3,2 2945 2130 7.19 [Ar]3d⁵4s¹ **Cr** Chromium	25 54.9380 7,6,4,2,3 2335 1517 7.43 [Ar]3d⁵4s² **Mn** Manganese	26 55.847 2,3 3135 1809 7.86 [Ar]3d⁶4s² **Fe** Iron	27 58.9332 2,3 3201 1768 8.90 [Ar]3d⁷4s² **Co** Cobalt	28 58.70 2,3 3187 1726 8.90 [Ar]3d⁸4s² **Ni** Nickel	29 63.546 2,1 2836 1357.6 8.96 [Ar]3d¹⁰4s¹ **Cu** Copper	30 65.38 2 1180 692.73 7.14 [Ar]3d¹⁰4s² **Zn** Zinc	31 69.72 3 2478 302.90 5.91 [Ar]3d¹⁰4s²p¹ **Ga** Gallium	32 72.59 4 3107 1210.4 5.32 [Ar]3d¹⁰4s²p² **Ge** Germanium	33 74.9215 ±3,5 876 (sub.) 1090 (triple) 5.72 [Ar]3d¹⁰4s²p³ **As** Arsenic	34 78.96 −2,4,6 958 494 4.80 [Ar]3d¹⁰4s²p⁴ **Se** Selenium	35 79.904 ±1,5 332.25 265.90 3.12 [Ar]3d¹⁰4s²p⁵ **Br** Bromine	36 83.80 119.80 115.78 3.74* [Ar]3d¹⁰4s²p⁶ **Kr** Krypton
37 85.4678 1 961 312.64 1.53 [Kr]5s¹ **Rb** Rubidium	38 87.62 2 1650 1041 2.6 [Kr]5s² **Sr** Strontium	39 88.9059 3 3611 1799 4.5 [Kr]4d¹5s² **Y** Yttrium	40 91.22 4 4682 2125 6.49 [Kr]4d²5s² **Zr** Zirconium	41 92.9064 5,3 5017 2740 8.55 [Kr]4d⁴5s¹ **Nb** Niobium	42 95.94 6,5,4,3,2 4912 2890 10.2 [Kr]4d⁵5s¹ **Mo** Molybdenum	43 (98) 7 4536 2473 11.5 [Kr]4d⁵5s² **Tc** Technetium	44 101.07 2,3,4,6,8 4423 2523 12.2 [Kr] 4d⁷5s¹ **Ru** Ruthenium	45 102.9055 2,3,4 3970 2236 12.4 [Kr]4d⁸5s¹ **Rh** Rhodium	46 106.4 2,4 3237 1825 12.0 [Kr]4d¹⁰ **Pd** Palladium	47 107.868 1 2436 1234 10.5 [Kr]4d¹⁰5s¹ **Ag** Silver	48 112.41 2 1040 594.18 8.65 [Kr]4d¹⁰5s² **Cd** Cadmium	49 114.82 3 2346 429.76 7.31 [Kr]4d¹⁰5s²p¹ **In** Indium	50 118.69 4,2 3876 505.06 7.30 [Kr]4d¹⁰5s²p² **Sn** Tin	51 121.75 ±3,5 1860 904 6.68 [Kr]4d¹⁰5s²p³ **Sb** Antimony	52 127.60 −2,4,6 1261 722.65 6.24 [Kr]4d¹⁰5s²p⁴ **Te** Tellurium	53 126.9045 ±1,5,7 458.4 386.7 4.92 [Kr]4d¹⁰5s²p⁵ **I** Iodine	54 131.30 165.03 161.36 5.89* [Kr]4d¹⁰5s²p⁶ **Xe** Xenon
55 132.9054 1 944 301.55 1.87 [Xe]6s¹ **Cs** Cesium	56 137.33 2 2171 1002 3.5 [Xe]6s² **Ba** Barium	57 138.9055 3 3730 1193 6.7 [Xe]5d¹6s² **La** ★ Lanthanum	72 178.49 4 4876 2500 13.1 [Xe]4f¹⁴5d²6s² **Hf** Hafnium	73 180.9479 5 5731 3287 16.6 [Xe]4f¹⁴5d³6s² **Ta** Tantalum	74 183.85 6,5,4,3,2 5828 3680 19.3 [Xe]4f¹⁴5d⁴6s² **W** Tungsten	75 186.207 7,6,4,2,−1 5869 3453 21.0 [Xe]4f¹⁴5d⁵6s² **Re** Rhenium	76 190.2 2,3,4,6,8 5285 3300 22.4 [Xe]4f¹⁴5d⁶6s² **Os** Osmium	77 192.22 2,3,4,6 4701 2716 22.5 [Xe]4f¹⁴5d⁷6s² **Ir** Iridium	78 195.09 2,4 4100 2045 21.4 [Xe]4f¹⁴5d⁹6s¹ **Pt** Platinum	79 196.9665 3,1 3130 1337.58 19.3 [Xe] 4f¹⁴5d¹⁰6s¹ **Au** Gold	80 200.59 2,1 630 234.28 13.53 [Xe]4f¹⁴5d¹⁰6s² **Hg** Mercury	81 204.37 3,1 1746 577 11.85 [Xe]4f¹⁴5d¹⁰6s²p¹ **Tl** Thallium	82 207.2 4,2 2023 600.6 11.4 [Xe]4f¹⁴5d¹⁰6s²p² **Pb** Lead	83 208.9804 3,5 1837 544.52 9.8 [Xe]4f¹⁴5d¹⁰6s²p³ **Bi** Bismuth	84 (209) 4,2 1235 527 9.4 [Xe]4f¹⁴5d¹⁰6s²p⁴ **Po** Polonium	85 (210) ±1,3,5,7 610 575 [Xe]4f¹⁴5d¹⁰6s²p⁵ **At** Astatine	86 (222) 211 202 9.91* [Xe]4f¹⁴5d¹⁰6s²p⁶ **Rn** Radon
87 (223) 1 950 300 — [Rn]7s¹ **Fr** Francium	88 226.0254 2 1809 973 5 [Rn]7s² **Ra** Radium	89 227.0278 3 3473 1323 10.07 [Rn]6d¹7s² **Ac** ★★ Actinium	104 (261) — [Rn]5f¹⁴6d²7s² † **Unq** (Unnilquadium)	105 (262) — [Rn]5f¹⁴6d³7s² † **Unp** (Unnilpentium)	106 (263) — [Rn]5f¹⁴6d⁴7s² † **Unh** (Unnilhexium)														

† The names and symbols of elements 104 - 106 are those recommended by IUPAC as systematic alternatives to those suggested by the purported discoverers. Berkeley (USA) researchers have proposed Rutherfordium, Rf, for element 104 and Hahnium, Ha, for element 105.

The A & B subgroup designations, applicable to elements in rows 4, 5, 6, and 7, are those recommended by the International Union of Pure and Applied Chemistry. It should be noted that some authors and organizations use the opposite convention in distinguishing these subgroups.

* Estimated Values

★	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	140.12 3,4 3699 1071 6.78 [Xe]4f¹5d¹6s² **Ce** Cerium	140.9077 3,4 3785 1204 6.77 [Xe]4f³6s² **Pr** Praseodymium	144.24 3 3341 1289 7.00 [Xe]4f⁴6s² **Nd** Neodymium	(145) 3 3785 1204 6.475 [Xe]4f⁵6s² **Pm** Promethium	150.4 3,2 2064 1345 7.54 [Xe]4f⁶6s² **Sm** Samarium	151.96 3,2 1870 1090 5.26 [Xe]4f⁷6s² **Eu** Europium	157.25 3 3539 1585 7.89 [Xe]4f⁷5d¹6s² **Gd** Gadolinium	158.9254 3,4 3496 1630 8.27 [Xe]4f⁹6s² **Tb** Terbium	162.50 3 2835 1682 8.54 [Xe]4f¹⁰6s² **Dy** Dysprosium	164.9304 3 2968 1743 8.80 [Xe]4f¹¹6s² **Ho** Holmium	167.26 3 3136 1795 9.05 [Xe]4f¹²6s² **Er** Erbium	168.9342 3,2 2220 1818 9.33 [Xe]4f¹³6s² **Tm** Thulium	173.04 3,2 1467 1097 6.98 [Xe]4f¹⁴6s² **Yb** Ytterbium	174.967 3 3668 1936 9.84 [Xe] 4f¹⁴5d¹6s² **Lu** Lutetium
★★	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	232.0381 4 5061 2029 11.7 [Rn]6d²7s² **Th** Thorium	231.0359 5,4 15.4 [Rn]5f²6d¹7s² **Pa** Protactinium	238.029 6,5,4,3 4407 1405 18.90 [Rn]5f³6d¹7s² **U** Uranium	237.0482 6,5,4,3 910 20.4 [Rn]5f⁴6d¹7s² **Np** Neptunium	(244) 6,5,4,3 3503 913 19.8 [Rn]5f⁶7s² **Pu** Plutonium	(243) 6,5,4,3 2880 1268 13.6 [Rn]5f⁷7s² **Am** Americium	(247) 3 1340 13.511 [Rn]5f⁷6d¹7s² **Cm** Curium	(247) 4,3 900 [Rn]5f⁹7s² **Bk** Berkelium	(251) 3 [Rn]5f¹⁰7s² **Cf** Californium	(252) — [Rn]5f¹¹7s² **Es** Einsteinium	(257) — [Rn]5f¹²7s² **Fm** Fermium	(258) — [Rn]5f¹³7s² **Md** Mendelevium	(259) — [Rn]5f¹⁴7s² **No** Nobelium	(260) — [Rn]5f¹⁴6d¹7s² **Lr** Lawrencium



NOTES:

(1) Black — solid.
Red — gas.
Blue — liquid.
Outline — synthetically prepared.

(2) Based upon carbon-12. ( ) indicates most stable or best known isotope.

(3) Entries marked with asterisks refer to the gaseous state at 273 K and 1 atm and are given in units of g/l.

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Catalog Number S-18806

Side 1

TABLE OF PERIODIC PROPERTIES OF THE ELEMENTS

Percent Ionic Character of a Single Chemical Bond

Difference in electronegativity	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0	3.1	3.2
Percent ionic character %	0.5	1	2	4	6	9	12	15	19	22	26	30	34	39	43	47	51	55	59	63	67	70	74	76	79	82	84	86	88	89	91	92

DATA CONCERNING THE MORE STABLE ELEMENTARY (SUBATOMIC) PARTICLES					
	Neutron	Proton	Electron*	Neutrino*	Photon
Symbol	n	p	e (e⁻)	ν	γ
Rest mass (kg)	1.67495×10^{-27}	1.67265×10^{-27}	9.1095×10^{-31}	~0	0
Relative atomic mass (^{12}C = 12)	1.008665	1.007276	5.48580×10^{-4}	~0	0
Charge (C)	0	1.60219×10^{-19}	-1.60219×10^{-19}	0	0
Radius (m)	8×10^{-16}	8×10^{-16}	$< 1 \times 10^{-16}$	~0	0
Spin quantum number	1/2	1/2	1/2	1/2	1
Magnetic Moment†	$-1.913\ \mu_N$	$2.793\ \mu_N$	$1.001\ \mu_B$	0	0

* The positron (e^+) has properties similar to those of the (negative) electron or beta particle except that its charge has opposite sign (+). The antineutrino ($\bar{\nu}$) has properties similar to those of the neutrino except that its spin (or rotation) is opposite in relation to its direction of propagation.

An antineutrino accompanies release of an electron in radioactive β (particle) decay, whereas a neutrino accompanies the release of a positron in β^+ decay.

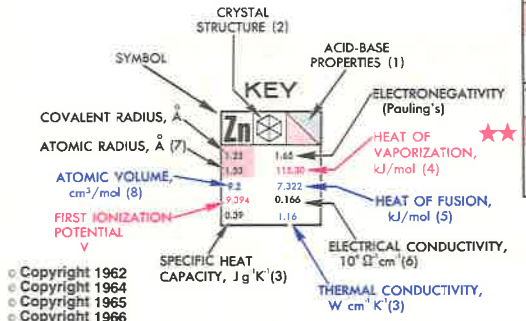
†μ_B=Bohr magneton and μ_N=Nuclear magneton.

GROUP IA	IIA	IIIA	IVA	VA	VIA	VIIA	VIIIA			IB	IIB	IIIB	IVB	VB	VIB	VIIB	VIII
H												B	C	N	O	F	He
Li	Be											Al	Si	P	S	Cl	Ne
Na	Mg																Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba	La*	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac**	Unq	UnP	Unh												

*	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
**	Th	Pa	U	NP	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr

† The names and symbols of elements 104 - 106 are those recommended by IUPAC as systematic alternatives to those suggested by the purported discoverers. Berkeley (USA) researchers have proposed Rutherfordium, Rf, for element 104 and Hahnium, Ha, for element 105. Dubna researchers, who also claim the discovery of these elements have proposed different names (and symbols).

The A & B subgroup designations, applicable to elements in rows 4, 5, 6, and 7, are those recommended by the International Union of Pure and Applied Chemistry. It should be noted that some authors and organizations use the opposite convention in distinguishing these subgroups.



NOTES: (1) For representative oxides (higher valence) of group. Oxide is acidic if color is red, basic if color is blue and amphoteric if both colors are shown. Intensity of color indicates relative strength.

(2) Cubic, face centered; cubic, body centered; cubic; hexagonal; rhombohedral; tetragonal; orthorhombic; monoclinic.

(3) At 300 K (27°C)

(4) At boiling point

(5) At melting point

(6) Generally at 293K (20°C) for polycrystalline material

(7) Quantum mechanical value for free atom

(8) From density at 300 K (27°C) for liquid and solid elements; values for gaseous elements refer to liquid state at boiling point

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