PERIODIC TABLE

Atomic Properties of the Elements

National Institute of Standards and Technology
U.S. Department of Commerce

Physical Measurement Laboratory www.nist.gov/pml
Standard Reference Data www.nist.gov/srd

FREQUENTLY USED FUNDAMENTAL PHYSICAL CONSTANTS§

1 second = 9 192 631 770 periods of radiation corresponding to the transition between the two hyperfine levels of the ground state of ^{133}Cs

speed of light in vacuum	c	299 792 458 m s^{-1}	(exact)
Planck constant	h	6.626 070 15 x 10^{-34} J Hz^{-1}	(exact)
elementary charge	e	1.602 176 634 x 10^{-19} C	(exact)
Avogadro constant	N_A	6.022 140 76 x 10^{23} mol^{-1}	(exact)
Boltzmann constant	k	1.380 649 x 10^{-23} J K^{-1}	(exact)
electron volt	eV	1.602 176 634 x 10^{-19} J	(exact)
electron mass	m_e	9.109 383 70 x 10^{-31} kg	
energy equivalent	$m_e c^2$	0.510 998 950 MeV	
proton mass	m_p	1.672 621 924 x 10^{-27} kg	
energy equivalent	$m_p c^2$	938.272 088 MeV	
fine-structure constant	α	1/137.035 999	
Rydberg energy	$R_\infty hc$	13.605 693 1230 eV	
Newtonian constant of gravitation	G	6.674 x 10^{-11} m^3 kg^{-1} s^{-2}	

§For the most accurate values of these and other constants, visit pml.nist.gov/constants.

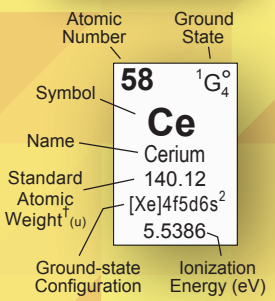
Solids
Liquids
Gases
Artificially Prepared

Group 1 IA | 2 IIA | 3 IIIB | 4 IVB | 5 VB | 6 VIB | 7 VIIB | 8 | 9 VIII | 10 | 11 IB | 12 IIB | 13 IIIA | 14 IVA | 15 VA | 16 VIA | 17 VIIA | 18 VIIIA

Period

Period	1 IA	2 IIA	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	8	9 VIII	10	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA
1	1 $^2S_{1/2}$ **H** Hydrogen 1.008 $1s$ 13.5984																	2 $^1S_0$ **He** Helium 4.0026 $1s^2$ 24.5874
2	3 $^2S_{1/2}$ **Li** Lithium 6.94 $1s^2 2s$ 5.3917	4 $^1S_0$ **Be** Beryllium 9.0122 $1s^2 2s^2$ 9.3227											5 $^2P^o_{1/2}$ **B** Boron 10.81 $1s^2 2s^2 2p$ 8.2980	6 $^3P_0$ **C** Carbon 12.011 $1s^2 2s^2 2p^2$ 11.2603	7 $^4S^o_{3/2}$ **N** Nitrogen 14.007 $1s^2 2s^2 2p^3$ 14.5341	8 $^3P_2$ **O** Oxygen 15.999 $1s^2 2s^2 2p^4$ 13.6181	9 $^2P^o_{3/2}$ **F** Fluorine 18.998 $1s^2 2s^2 2p^5$ 17.4228	10 $^1S_0$ **Ne** Neon 20.180 $1s^2 2s^2 2p^6$ 21.5645
3	11 $^2S_{1/2}$ **Na** Sodium 22.990 [Ne]$3s$ 5.1391	12 $^1S_0$ **Mg** Magnesium 24.305 [Ne]$3s^2$ 7.6462											13 $^2P^o_{1/2}$ **Al** Aluminum 26.982 [Ne]$3s^2 3p$ 5.9858	14 $^3P_0$ **Si** Silicon 28.085 [Ne]$3s^2 3p^2$ 8.1517	15 $^4S^o_{3/2}$ **P** Phosphorus 30.974 [Ne]$3s^2 3p^3$ 10.4867	16 $^3P_2$ **S** Sulfur 32.06 [Ne]$3s^2 3p^4$ 10.3600	17 $^2P^o_{3/2}$ **Cl** Chlorine 35.45 [Ne]$3s^2 3p^5$ 12.9676	18 $^1S_0$ **Ar** Argon 39.948 [Ne]$3s^2 3p^6$ 15.7596
4	19 $^2S_{1/2}$ **K** Potassium 39.098 [Ar]$4s$ 4.3407	20 $^1S_0$ **Ca** Calcium 40.078 [Ar]$4s^2$ 6.1132	21 $^2D_{3/2}$ **Sc** Scandium 44.956 [Ar]$3d4s^2$ 6.5615	22 $^3F_2$ **Ti** Titanium 47.867 [Ar]$3d^2 4s^2$ 6.8281	23 $^4F_{3/2}$ **V** Vanadium 50.942 [Ar]$3d^3 4s^2$ 6.7462	24 $^7S_3$ **Cr** Chromium 51.996 [Ar]$3d^5 4s$ 6.7665	25 $^6S_{5/2}$ **Mn** Manganese 54.938 [Ar]$3d^5 4s^2$ 7.4340	26 $^5D_4$ **Fe** Iron 55.845 [Ar]$3d^6 4s^2$ 7.9025	27 $^4F_{9/2}$ **Co** Cobalt 58.933 [Ar]$3d^7 4s^2$ 7.8810	28 $^3F_4$ **Ni** Nickel 58.693 [Ar]$3d^8 4s^2$ 7.6399	29 $^2S_{1/2}$ **Cu** Copper 63.546 [Ar]$3d^{10} 4s$ 7.7264	30 $^1S_0$ **Zn** Zinc 65.38 [Ar]$3d^{10} 4s^2$ 9.3942	31 $^2P^o_{1/2}$ **Ga** Gallium 69.723 [Ar]$3d^{10} 4s^2 4p$ 5.9993	32 $^3P_0$ **Ge** Germanium 72.630 [Ar]$3d^{10} 4s^2 4p^2$ 7.8994	33 $^4S^o_{3/2}$ **As** Arsenic 74.922 [Ar]$3d^{10} 4s^2 4p^3$ 9.7886	34 $^3P_2$ **Se** Selenium 78.971 [Ar]$3d^{10} 4s^2 4p^4$ 9.7524	35 $^2P^o_{3/2}$ **Br** Bromine 79.904 [Ar]$3d^{10} 4s^2 4p^5$ 11.8138	36 $^1S_0$ **Kr** Krypton 83.798 [Ar]$3d^{10} 4s^2 4p^6$ 13.9996
5	37 $^2S_{1/2}$ **Rb** Rubidium 85.468 [Kr]$5s$ 4.1771	38 $^1S_0$ **Sr** Strontium 87.62 [Kr]$5s^2$ 5.6949	39 $^2D_{3/2}$ **Y** Yttrium 88.906 [Kr]$4d5s^2$ 6.2173	40 $^3F_2$ **Zr** Zirconium 91.224 [Kr]$4d^2 5s^2$ 6.6341	41 $^6D_{1/2}$ **Nb** Niobium 92.906 [Kr]$4d^4 5s$ 6.7589	42 $^7S_3$ **Mo** Molybdenum 95.95 [Kr]$4d^5 5s$ 7.0924	43 $^6S_{5/2}$ **Tc** Technetium (97) [Kr]$4d^5 5s^2$ 7.1194	44 $^5F_5$ **Ru** Ruthenium 101.07 [Kr]$4d^7 5s$ 7.3605	45 $^4F_{9/2}$ **Rh** Rhodium 102.91 [Kr]$4d^8 5s$ 7.4589	46 $^1S_0$ **Pd** Palladium 106.42 [Kr]$4d^{10}$ 8.3368	47 $^2S_{1/2}$ **Ag** Silver 107.87 [Kr]$4d^{10} 5s$ 7.5762	48 $^1S_0$ **Cd** Cadmium 112.41 [Kr]$4d^{10} 5s^2$ 8.9938	49 $^2P^o_{1/2}$ **In** Indium 114.82 [Kr]$4d^{10} 5s^2 5p$ 5.7864	50 $^3P_0$ **Sn** Tin 118.71 [Kr]$4d^{10} 5s^2 5p^2$ 7.3439	51 $^4S^o_{3/2}$ **Sb** Antimony 121.76 [Kr]$4d^{10} 5s^2 5p^3$ 8.6084	52 $^3P_2$ **Te** Tellurium 127.60 [Kr]$4d^{10} 5s^2 5p^4$ 9.0098	53 $^2P^o_{3/2}$ **I** Iodine 126.90 [Kr]$4d^{10} 5s^2 5p^5$ 10.4513	54 $^1S_0$ **Xe** Xenon 131.29 [Kr]$4d^{10} 5s^2 5p^6$ 12.1298
6	55 $^2S_{1/2}$ **Cs** Cesium 132.91 [Xe]$6s$ 3.8939	56 $^1S_0$ **Ba** Barium 137.33 [Xe]$6s^2$ 5.2117		72 $^3F_2$ **Hf** Hafnium 178.49 [Xe]$4f^{14} 5d^2 6s^2$ 6.8251	73 $^4F_{3/2}$ **Ta** Tantalum 180.95 [Xe]$4f^{14} 5d^3 6s^2$ 7.5496	74 $^5D_0$ **W** Tungsten 183.84 [Xe]$4f^{14} 5d^4 6s^2$ 7.8640	75 $^6S_{5/2}$ **Re** Rhenium 186.21 [Xe]$4f^{14} 5d^5 6s^2$ 7.8335	76 $^5D_4$ **Os** Osmium 190.23 [Xe]$4f^{14} 5d^6 6s^2$ 8.4382	77 $^4F_{9/2}$ **Ir** Iridium 192.22 [Xe]$4f^{14} 5d^7 6s^2$ 8.9670	78 $^3D_3$ **Pt** Platinum 195.08 [Xe]$4f^{14} 5d^9 6s$ 8.9588	79 $^2S_{1/2}$ **Au** Gold 196.97 [Xe]$4f^{14} 5d^{10} 6s$ 9.2256	80 $^1S_0$ **Hg** Mercury 200.59 [Xe]$4f^{14} 5d^{10} 6s^2$ 10.4375	81 $^2P^o_{1/2}$ **Tl** Thallium 204.38 [Hg]$6p$ 6.1083	82 $^3P_0$ **Pb** Lead 207.2 [Hg]$6p^2$ 7.4167	83 $^4S^o_{3/2}$ **Bi** Bismuth 208.98 [Hg]$6p^3$ 7.2855	84 $^3P_2$ **Po** Polonium (209) [Hg]$6p^4$ 8.4181	85 $^2P^o_{3/2}$ **At** Astatine (210) [Hg]$6p^5$ 9.3175	86 $^1S_0$ **Rn** Radon (222) [Hg]$6p^6$ 10.7485
7	87 $^2S_{1/2}$ **Fr** Francium (223) [Rn]$7s$ 4.0727	88 $^1S_0$ **Ra** Radium (226) [Rn]$7s^2$ 5.2784		104 $^3F_2$ **Rf** Rutherfordium (267) [Rn]$5f^{14} 6d^2 7s^2$ 6.02	105 $^4F_{3/2}$ **Db** Dubnium (268) [Rn]$5f^{14} 6d^3 7s^2$ 6.8	106 ^{0} **Sg** Seaborgium (269) [Rn]$5f^{14} 6d^4 7s^2$ 7.8	107 $^{5/2}$ **Bh** Bohrium (270) [Rn]$5f^{14} 6d^5 7s^2$ 7.7	108 ^{4} **Hs** Hassium (269) [Rn]$5f^{14} 6d^6 7s^2$ 7.6	109 **Mt** Meitnerium (278)	110 **Ds** Darmstadtium (281)	111 **Rg** Roentgenium (282)	112 **Cn** Copernicium (285)	113 **Nh** Nihonium (286)	114 **Fl** Flerovium (289)	115 **Mc** Moscovium (289)	116 **Lv** Livermorium (293)	117 **Ts** Tennessine (294)	118 **Og** Oganesson (294)

Lanthanides	57 $^2D_{3/2}$ **La** Lanthanum 138.91 [Xe]$5d6s^2$ 5.5769	58 $^1G^o_4$ **Ce** Cerium 140.12 [Xe]$4f5d6s^2$ 5.5386	59 $^4I^o_{9/2}$ **Pr** Praseodymium 140.91 [Xe]$4f^3 6s^2$ 5.4702	60 $^5I_4$ **Nd** Neodymium 144.24 [Xe]$4f^4 6s^2$ 5.5250	61 $^6H^o_{5/2}$ **Pm** Promethium (145) [Xe]$4f^5 6s^2$ 5.5819	62 $^7F_0$ **Sm** Samarium 150.36 [Xe]$4f^6 6s^2$ 5.6437	63 $^8S^o_{7/2}$ **Eu** Europium 151.96 [Xe]$4f^7 6s^2$ 5.6704	64 $^9D^o_2$ **Gd** Gadolinium 157.25 [Xe]$4f^7 5d6s^2$ 6.1498	65 $^6H^o_{15/2}$ **Tb** Terbium 158.93 [Xe]$4f^9 6s^2$ 5.8638	66 $^5I_8$ **Dy** Dysprosium 162.50 [Xe]$4f^{10} 6s^2$ 5.9391	67 $^4I^o_{15/2}$ **Ho** Holmium 164.93 [Xe]$4f^{11} 6s^2$ 6.0215	68 $^3H_6$ **Er** Erbium 167.26 [Xe]$4f^{12} 6s^2$ 6.1077	69 $^2F^o_{7/2}$ **Tm** Thulium 168.93 [Xe]$4f^{13} 6s^2$ 6.1844	70 $^1S_0$ **Yb** Ytterbium 173.05 [Xe]$4f^{14} 6s^2$ 6.2542	71 $^2D_{3/2}$ **Lu** Lutetium 174.97 [Xe]$4f^{14} 5d6s^2$ 5.4259
Actinides	89 $^2D_{3/2}$ **Ac** Actinium (227) [Rn]$6d7s^2$ 5.3802	90 $^3F_2$ **Th** Thorium 232.04 [Rn]$6d^2 7s^2$ 6.3067	91 $^4K_{11/2}$ **Pa** Protactinium 231.04 [Rn]$5f^2 6d7s^2$ 5.89	92 $^5L_6$ **U** Uranium 238.03 [Rn]$5f^3 6d7s^2$ 6.1941	93 $^6L_{11/2}$ **Np** Neptunium (237) [Rn]$5f^4 6d7s^2$ 6.2655	94 $^7F_0$ **Pu** Plutonium (244) [Rn]$5f^6 7s^2$ 6.0258	95 $^8S^o_{7/2}$ **Am** Americium (243) [Rn]$5f^7 7s^2$ 5.9738	96 $^9D^o_2$ **Cm** Curium (247) [Rn]$5f^7 6d7s^2$ 5.9914	97 $^6H^o_{15/2}$ **Bk** Berkelium (247) [Rn]$5f^9 7s^2$ 6.1979	98 $^5I_8$ **Cf** Californium (251) [Rn]$5f^{10} 7s^2$ 6.2819	99 $^4I^o_{15/2}$ **Es** Einsteinium (252) [Rn]$5f^{11} 7s^2$ 6.3676	100 $^3H_6$ **Fm** Fermium (257) [Rn]$5f^{12} 7s^2$ 6.50	101 $^2F^o_{7/2}$ **Md** Mendelevium (258) [Rn]$5f^{13} 7s^2$ 6.58	102 $^1S_0$ **No** Nobelium (259) [Rn]$5f^{14} 7s^2$ 6.6262	103 $^2P^o_{1/2}$ **Lr** Lawrencium (266) [Rn]$5f^{14} 7s^2 7p$ 4.96



†Based upon ^{12}C. () indicates the mass number of the longest-lived isotope.

For the most precise values and uncertainties visit ciaaw.org and pml.nist.gov/data.

NIST SP 966 (August 2022)

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347,100 Total Compounds

60% Increase in Size

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