PERIODIC TABLE
Atomic Properties of the Elements

NIST 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 71 x 10^{-31} kg	
energy equivalent	m_ec^2	0.510 998 951 MeV	
proton mass	m_p	1.672 621 926 x 10^{-27} kg	
energy equivalent	m_pc^2	938.272 089 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, 8–10 VIII, 11 IB, 12 IIB, 13 IIIA, 14 IVA, 15 VA, 16 VIA, 17 VIIA, 18 VIIIA

Period: 1–7

Lanthanides; Actinides

Key: Atomic Number (58), Ground State ($^1G^\circ_4$), Symbol (Ce), Name (Cerium), Standard Atomic Weight†(u) (140.12), Ground-state Configuration ($[Xe]4f5d6s^2$), Ionization Energy (eV) (5.5386)

Atomic Number	Symbol	Name	Ground State	Standard Atomic Weight† (u)	Ground-state Configuration	Ionization Energy (eV)
1	H	Hydrogen	$^2S_{1/2}$	1.008	$1s$	13.5984
2	He	Helium	$^1S_0$	4.0026	$1s^2$	24.5874
3	Li	Lithium	$^2S_{1/2}$	6.94	$1s^22s$	5.3917
4	Be	Beryllium	$^1S_0$	9.0122	$1s^22s^2$	9.3227
5	B	Boron	$^2P^\circ_{1/2}$	10.81	$1s^22s^22p$	8.2980
6	C	Carbon	$^3P_0$	12.011	$1s^22s^22p^2$	11.2603
7	N	Nitrogen	$^4S^\circ_{3/2}$	14.007	$1s^22s^22p^3$	14.5341
8	O	Oxygen	$^3P_2$	15.999	$1s^22s^22p^4$	13.6181
9	F	Fluorine	$^2P^\circ_{3/2}$	18.998	$1s^22s^22p^5$	17.4228
10	Ne	Neon	$^1S_0$	20.180	$1s^22s^22p^6$	21.5645
11	Na	Sodium	$^2S_{1/2}$	22.990	$[Ne]3s$	5.1391
12	Mg	Magnesium	$^1S_0$	24.305	$[Ne]3s^2$	7.6462
13	Al	Aluminum	$^2P^\circ_{1/2}$	26.982	$[Ne]3s^23p$	5.9858
14	Si	Silicon	$^3P_0$	28.085	$[Ne]3s^23p^2$	8.1517
15	P	Phosphorus	$^4S^\circ_{3/2}$	30.974	$[Ne]3s^23p^3$	10.4867
16	S	Sulfur	$^3P_2$	32.06	$[Ne]3s^23p^4$	10.3600
17	Cl	Chlorine	$^2P^\circ_{3/2}$	35.45	$[Ne]3s^23p^5$	12.9676
18	Ar	Argon	$^1S_0$	39.95	$[Ne]3s^23p^6$	15.7596
19	K	Potassium	$^2S_{1/2}$	39.098	$[Ar]4s$	4.3407
20	Ca	Calcium	$^1S_0$	40.078	$[Ar]4s^2$	6.1132
21	Sc	Scandium	$^2D_{3/2}$	44.956	$[Ar]3d4s^2$	6.5615
22	Ti	Titanium	$^3F_2$	47.867	$[Ar]3d^24s^2$	6.8281
23	V	Vanadium	$^4F_{3/2}$	50.942	$[Ar]3d^34s^2$	6.7462
24	Cr	Chromium	$^7S_3$	51.996	$[Ar]3d^54s$	6.7665
25	Mn	Manganese	$^6S_{5/2}$	54.938	$[Ar]3d^54s^2$	7.4340
26	Fe	Iron	$^5D_4$	55.845	$[Ar]3d^64s^2$	7.9025
27	Co	Cobalt	$^4F_{9/2}$	58.933	$[Ar]3d^74s^2$	7.8810
28	Ni	Nickel	$^3F_4$	58.693	$[Ar]3d^84s^2$	7.6399
29	Cu	Copper	$^2S_{1/2}$	63.546	$[Ar]3d^{10}4s$	7.7264
30	Zn	Zinc	$^1S_0$	65.38	$[Ar]3d^{10}4s^2$	9.3942
31	Ga	Gallium	$^2P^\circ_{1/2}$	69.723	$[Ar]3d^{10}4s^24p$	5.9993
32	Ge	Germanium	$^3P_0$	72.630	$[Ar]3d^{10}4s^24p^2$	7.8994
33	As	Arsenic	$^4S^\circ_{3/2}$	74.922	$[Ar]3d^{10}4s^24p^3$	9.7886
34	Se	Selenium	$^3P_2$	78.971	$[Ar]3d^{10}4s^24p^4$	9.7524
35	Br	Bromine	$^2P^\circ_{3/2}$	79.904	$[Ar]3d^{10}4s^24p^5$	11.8138
36	Kr	Krypton	$^1S_0$	83.798	$[Ar]3d^{10}4s^24p^6$	13.9996
37	Rb	Rubidium	$^2S_{1/2}$	85.468	$[Kr]5s$	4.1771
38	Sr	Strontium	$^1S_0$	87.62	$[Kr]5s^2$	5.6949
39	Y	Yttrium	$^2D_{3/2}$	88.906	$[Kr]4d5s^2$	6.2173
40	Zr	Zirconium	$^3F_2$	91.224	$[Kr]4d^25s^2$	6.6341
41	Nb	Niobium	$^6D_{1/2}$	92.906	$[Kr]4d^45s$	6.7589
42	Mo	Molybdenum	$^7S_3$	95.95	$[Kr]4d^55s$	7.0924
43	Tc	Technetium	$^6S_{5/2}$	(97)	$[Kr]4d^55s^2$	7.1194
44	Ru	Ruthenium	$^5F_5$	101.07	$[Kr]4d^75s$	7.3605
45	Rh	Rhodium	$^4F_{9/2}$	102.91	$[Kr]4d^85s$	7.4589
46	Pd	Palladium	$^1S_0$	106.42	$[Kr]4d^{10}$	8.3368
47	Ag	Silver	$^2S_{1/2}$	107.87	$[Kr]4d^{10}5s$	7.5762
48	Cd	Cadmium	$^1S_0$	112.41	$[Kr]4d^{10}5s^2$	8.9938
49	In	Indium	$^2P^\circ_{1/2}$	114.82	$[Kr]4d^{10}5s^25p$	5.7864
50	Sn	Tin	$^3P_0$	118.71	$[Kr]4d^{10}5s^25p^2$	7.3439
51	Sb	Antimony	$^4S^\circ_{3/2}$	121.76	$[Kr]4d^{10}5s^25p^3$	8.6084
52	Te	Tellurium	$^3P_2$	127.60	$[Kr]4d^{10}5s^25p^4$	9.0098
53	I	Iodine	$^2P^\circ_{3/2}$	126.90	$[Kr]4d^{10}5s^25p^5$	10.4512
54	Xe	Xenon	$^1S_0$	131.29	$[Kr]4d^{10}5s^25p^6$	12.1298
55	Cs	Cesium	$^2S_{1/2}$	132.91	$[Xe]6s$	3.8939
56	Ba	Barium	$^1S_0$	137.33	$[Xe]6s^2$	5.2117
57	La	Lanthanum	$^2D_{3/2}$	138.91	$[Xe]5d6s^2$	5.5769
58	Ce	Cerium	$^1G^\circ_4$	140.12	$[Xe]4f5d6s^2$	5.5386
59	Pr	Praseodymium	$^4I^\circ_{9/2}$	140.91	$[Xe]4f^36s^2$	5.4702
60	Nd	Neodymium	$^5I_4$	144.24	$[Xe]4f^46s^2$	5.5250
61	Pm	Promethium	$^6H^\circ_{5/2}$	(145)	$[Xe]4f^56s^2$	5.5819
62	Sm	Samarium	$^7F_0$	150.36	$[Xe]4f^66s^2$	5.6437
63	Eu	Europium	$^8S^\circ_{7/2}$	151.96	$[Xe]4f^76s^2$	5.6704
64	Gd	Gadolinium	$^9D^\circ_2$	157.25	$[Xe]4f^75d6s^2$	6.1498
65	Tb	Terbium	$^6H^\circ_{15/2}$	158.93	$[Xe]4f^96s^2$	5.8638
66	Dy	Dysprosium	$^5I_8$	162.50	$[Xe]4f^{10}6s^2$	5.9391
67	Ho	Holmium	$^4I^\circ_{15/2}$	164.93	$[Xe]4f^{11}6s^2$	6.0215
68	Er	Erbium	$^3H_6$	167.26	$[Xe]4f^{12}6s^2$	6.1077
69	Tm	Thulium	$^2F^\circ_{7/2}$	168.93	$[Xe]4f^{13}6s^2$	6.1844
70	Yb	Ytterbium	$^1S_0$	173.05	$[Xe]4f^{14}6s^2$	6.2542
71	Lu	Lutetium	$^2D_{3/2}$	174.97	$[Xe]4f^{14}5d6s^2$	5.4259
72	Hf	Hafnium	$^3F_2$	178.49	$[Xe]4f^{14}5d^26s^2$	6.8251
73	Ta	Tantalum	$^4F_{3/2}$	180.95	$[Xe]4f^{14}5d^36s^2$	7.5496
74	W	Tungsten	$^5D_0$	183.84	$[Xe]4f^{14}5d^46s^2$	7.8640
75	Re	Rhenium	$^6S_{5/2}$	186.21	$[Xe]4f^{14}5d^56s^2$	7.8335
76	Os	Osmium	$^5D_4$	190.23	$[Xe]4f^{14}5d^66s^2$	8.4382
77	Ir	Iridium	$^4F_{9/2}$	192.22	$[Xe]4f^{14}5d^76s^2$	8.9670
78	Pt	Platinum	$^3D_3$	195.08	$[Xe]4f^{14}5d^96s$	8.9588
79	Au	Gold	$^2S_{1/2}$	196.97	$[Xe]4f^{14}5d^{10}6s$	9.2256
80	Hg	Mercury	$^1S_0$	200.59	$[Xe]4f^{14}5d^{10}6s^2$	10.4375
81	Tl	Thallium	$^2P^\circ_{1/2}$	204.38	$[Hg]6p$	6.1083
82	Pb	Lead	$^3P_0$	207.2	$[Hg]6p^2$	7.4167
83	Bi	Bismuth	$^4S^\circ_{3/2}$	208.98	$[Hg]6p^3$	7.2855
84	Po	Polonium	$^3P_2$	(209)	$[Hg]6p^4$	8.4181
85	At	Astatine	$^2P^\circ_{3/2}$	(210)	$[Hg]6p^5$	9.3175
86	Rn	Radon	$^1S_0$	(222)	$[Hg]6p^6$	10.7485
87	Fr	Francium	$^2S_{1/2}$	(223)	$[Rn]7s$	4.0727
88	Ra	Radium	$^1S_0$	(226)	$[Rn]7s^2$	5.2784
89	Ac	Actinium	$^2D_{3/2}$	(227)	$[Rn]6d7s^2$	5.3802
90	Th	Thorium	$^3F_2$	232.04	$[Rn]6d^27s^2$	6.3067
91	Pa	Protactinium	$^4K_{11/2}$	231.04	$[Rn]5f^26d7s^2$	5.89
92	U	Uranium	$^5L^\circ_6$	238.03	$[Rn]5f^36d7s^2$	6.1941
93	Np	Neptunium	$^6L_{11/2}$	(237)	$[Rn]5f^46d7s^2$	6.2655
94	Pu	Plutonium	$^7F_0$	(244)	$[Rn]5f^67s^2$	6.0258
95	Am	Americium	$^8S^\circ_{7/2}$	(243)	$[Rn]5f^77s^2$	5.9738
96	Cm	Curium	$^9D^\circ_2$	(247)	$[Rn]5f^76d7s^2$	5.9922
97	Bk	Berkelium	$^6H^\circ_{15/2}$	(247)	$[Rn]5f^97s^2$	6.1979
98	Cf	Californium	$^5I_8$	(251)	$[Rn]5f^{10}7s^2$	6.2819
99	Es	Einsteinium	$^4I^\circ_{15/2}$	(252)	$[Rn]5f^{11}7s^2$	6.3684
100	Fm	Fermium	$^3H_6$	(257)	$[Rn]5f^{12}7s^2$	6.50
101	Md	Mendelevium	$^2F^\circ_{7/2}$	(258)	$[Rn]5f^{13}7s^2$	6.58
102	No	Nobelium	$^1S_0$	(259)	$[Rn]5f^{14}7s^2$	6.6262
103	Lr	Lawrencium	$^2P^\circ_{1/2}$	(262)	$[Rn]5f^{14}7s^27p$	4.96
104	Rf	Rutherfordium	$^3F_2$	(267)	$[Rn]5f^{14}6d^27s^2$	6.02
105	Db	Dubnium	$^4F_{3/2}$	(268)	$[Rn]5f^{14}6d^37s^2$	6.8
106	Sg	Seaborgium	$_0$	(269)	$[Rn]5f^{14}6d^47s^2$	7.8
107	Bh	Bohrium	$_{5/2}$	(270)	$[Rn]5f^{14}6d^57s^2$	7.7
108	Hs	Hassium	$_4$	(269)	$[Rn]5f^{14}6d^67s^2$	7.6
109	Mt	Meitnerium		(277)		
110	Ds	Darmstadtium		(281)		
111	Rg	Roentgenium		(282)		
112	Cn	Copernicium		(285)		
113	Nh	Nihonium		(286)		
114	Fl	Flerovium		(290)		
115	Mc	Moscovium		(290)		
116	Lv	Livermorium		(293)		
117	Ts	Tennessine		(294)		
118	Og	Oganesson		(294)		

†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.

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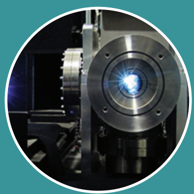
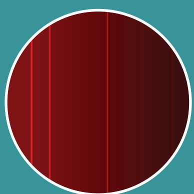
NISTory of the Periodic Table



Deuterium

This rare heavy isotope of hydrogen was distilled from liquid hydrogen at NIST and identified by Columbia University's Harold Urey (Nobel Prize 1934).

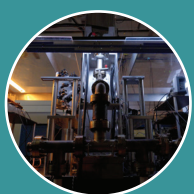
Image Credit: Uwe Arp/NIST



Krypton

The wavelength of light from this atom was used to define the official meter until 1983.

Image Credit: Neil Tucker/Wikimedia



Cesium

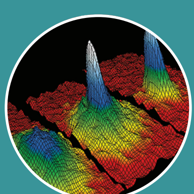
The frequency of light absorbed by this atom, measured by atomic clocks such as NIST-F4, has been used to officially define the second since 1967.

Image Credit: NIST

Sodium

A gas of these atoms was cooled with lasers by NIST scientists to reach temperatures near absolute zero (Nobel Prize 1997).

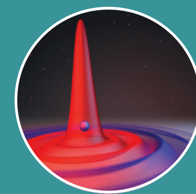
Image Credit: H. Mark Helfer/NIST



Rubidium

Researchers at JILA (NIST-CU Boulder) used these atoms to create a new state of matter called a Bose-Einstein condensate (Nobel Prize 2001).

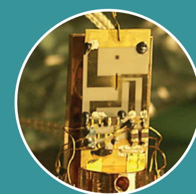
Image Credit: NIST/JILA/CU-Boulder



Potassium

JILA researcher Debbie Jin and her colleagues coaxed pairs of these atoms into forming another new state of matter known as a fermionic condensate.

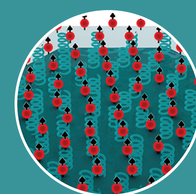
Image Credit: JILA



Aluminum

Electrically charged versions of these atoms (ions) have been used to create "quantum logic" clocks with record accuracy.

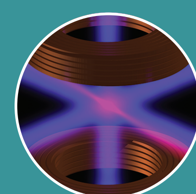
Image Credit: NIST



Beryllium

Ions of these atoms have performed quantum logic operations that could lay groundwork for future quantum computers.

Image Credit: S. Burrows/JILA



Strontium and Ytterbium

NIST and JILA researchers trapped thousands of these atoms in webs of light known as optical lattices to create ultraprecise and stable atomic clocks.

Image Credit: NIST

Charlotte Moore Sitterly

From 1945 to 1985, this NIST astrophysicist published critically reviewed tables of atomic data, establishing the agency as an authoritative source of this information.

Image Credit: NIST

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