PERIODIC TABLE

Atomic Properties of the Elements

National Institute of Standards and Technology
U.S. Department of Commerce
Physical Measurement Laboratory www.pml.nist.gov
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 x 10^{-34} J s	($\hbar = h/2\pi$)
elementary charge	e	1.602 177 x 10^{-19} C	
electron mass	m_e	9.109 384 x 10^{-31} kg	
	$m_e c^2$	0.510 999 MeV	
proton mass	m_p	1.672 622 x 10^{-27} kg	
fine-structure constant	α	1/137.035 999	
Rydberg constant	R_∞	10 973 731.569 m^{-1}	
	$R_\infty c$	3.289 841 960 x 10^{15} Hz	
	$R_\infty hc$	13.605 693 eV	
electron volt	eV	1.602 177 x 10^{-19} J	
Boltzmann constant	k	1.380 65 x 10^{-23} J K^{-1}	
molar gas constant	R	8.314 5 J mol^{-1} K^{-1}	

§ 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 1

1																	2
$^2S_{1/2}$																	$^1S_0$
H																	**He**
Hydrogen																	Helium
1.008*																	4.002602
$1s$																	$1s^2$
13.5984																	24.5874

Period 2

3	4											5	6	7	8	9	10
$^2S_{1/2}$	$^1S_0$											$^2P^o_{1/2}$	$^3P_0$	$^4S^o_{3/2}$	$^3P_2$	$^2P^o_{3/2}$	$^1S_0$
Li	**Be**											**B**	**C**	**N**	**O**	**F**	**Ne**
Lithium	Beryllium											Boron	Carbon	Nitrogen	Oxygen	Fluorine	Neon
6.94*	9.0121831											10.81*	12.011*	14.007*	15.999*	18.99840316*	20.1797
$1s^22s$	$1s^22s^2$											$1s^22s^22p$	$1s^22s^22p^2$	$1s^22s^22p^3$	$1s^22s^22p^4$	$1s^22s^22p^5$	$1s^22s^22p^6$
5.3917	9.3227											8.2980	11.2603	14.5341	13.6181	17.4228	21.5645

Period 3

11	12											13	14	15	16	17	18
$^2S_{1/2}$	$^1S_0$											$^2P^o_{1/2}$	$^3P_0$	$^4S^o_{3/2}$	$^3P_2$	$^2P^o_{3/2}$	$^1S_0$
Na	**Mg**											**Al**	**Si**	**P**	**S**	**Cl**	**Ar**
Sodium	Magnesium											Aluminum	Silicon	Phosphorus	Sulfur	Chlorine	Argon
22.98976928	24.305*											26.9815385	28.085*	30.97376199*	32.06*	35.45*	39.948
$[Ne]3s$	$[Ne]3s^2$											$[Ne]3s^23p$	$[Ne]3s^23p^2$	$[Ne]3s^23p^3$	$[Ne]3s^23p^4$	$[Ne]3s^23p^5$	$[Ne]3s^23p^6$
5.1391	7.6462											5.9858	8.1517	10.4867	10.3600	12.9676	15.7596

Period 4

19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
$^2S_{1/2}$	$^1S_0$	$^2D_{3/2}$	$^3F_2$	$^4F_{3/2}$	$^7S_3$	$^6S_{5/2}$	$^5D_4$	$^4F_{9/2}$	$^3F_4$	$^2S_{1/2}$	$^1S_0$	$^2P^o_{1/2}$	$^3P_0$	$^4S^o_{3/2}$	$^3P_2$	$^2P^o_{3/2}$	$^1S_0$
K	**Ca**	**Sc**	**Ti**	**V**	**Cr**	**Mn**	**Fe**	**Co**	**Ni**	**Cu**	**Zn**	**Ga**	**Ge**	**As**	**Se**	**Br**	**Kr**
Potassium	Calcium	Scandium	Titanium	Vanadium	Chromium	Manganese	Iron	Cobalt	Nickel	Copper	Zinc	Gallium	Germanium	Arsenic	Selenium	Bromine	Krypton
39.0983	40.078	44.955908	47.867	50.9415	51.9961	54.938044	55.845	58.933194	58.6934	63.546	65.38	69.723	72.630	74.921595	78.971	79.904*	83.798
$[Ar]4s$	$[Ar]4s^2$	$[Ar]3d4s^2$	$[Ar]3d^24s^2$	$[Ar]3d^34s^2$	$[Ar]3d^54s$	$[Ar]3d^54s^2$	$[Ar]3d^64s^2$	$[Ar]3d^74s^2$	$[Ar]3d^84s^2$	$[Ar]3d^{10}4s$	$[Ar]3d^{10}4s^2$	$[Ar]3d^{10}4s^24p$	$[Ar]3d^{10}4s^24p^2$	$[Ar]3d^{10}4s^24p^3$	$[Ar]3d^{10}4s^24p^4$	$[Ar]3d^{10}4s^24p^5$	$[Ar]3d^{10}4s^24p^6$
4.3407	6.1132	6.5615	6.8281	6.7462	6.7665	7.4340	7.9025	7.8810	7.6399	7.7264	9.3942	5.9993	7.8994	9.7886	9.7524	11.8138	13.9996

Period 5

37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54
$^2S_{1/2}$	$^1S_0$	$^2D_{3/2}$	$^3F_2$	$^6D_{1/2}$	$^7S_3$	$^6S_{5/2}$	$^5F_5$	$^4F_{9/2}$	$^1S_0$	$^2S_{1/2}$	$^1S_0$	$^2P^o_{1/2}$	$^3P_0$	$^4S^o_{3/2}$	$^3P_2$	$^2P^o_{3/2}$	$^1S_0$
Rb	**Sr**	**Y**	**Zr**	**Nb**	**Mo**	**Tc**	**Ru**	**Rh**	**Pd**	**Ag**	**Cd**	**In**	**Sn**	**Sb**	**Te**	**I**	**Xe**
Rubidium	Strontium	Yttrium	Zirconium	Niobium	Molybdenum	Technetium	Ruthenium	Rhodium	Palladium	Silver	Cadmium	Indium	Tin	Antimony	Tellurium	Iodine	Xenon
85.4678	87.62	88.90584	91.224	92.90637	95.95	(98)	101.07	102.90550	106.42	107.8682	112.414	114.818	118.710	121.760	127.60	126.90447	131.293
$[Kr]5s$	$[Kr]5s^2$	$[Kr]4d5s^2$	$[Kr]4d^25s^2$	$[Kr]4d^45s$	$[Kr]4d^55s$	$[Kr]4d^55s^2$	$[Kr]4d^75s$	$[Kr]4d^85s$	$[Kr]4d^{10}$	$[Kr]4d^{10}5s$	$[Kr]4d^{10}5s^2$	$[Kr]4d^{10}5s^25p$	$[Kr]4d^{10}5s^25p^2$	$[Kr]4d^{10}5s^25p^3$	$[Kr]4d^{10}5s^25p^4$	$[Kr]4d^{10}5s^25p^5$	$[Kr]4d^{10}5s^25p^6$
4.1771	5.6949	6.2173	6.6339	6.7589	7.0924	7.1194	7.3605	7.4589	8.3369	7.5762	8.9938	5.7864	7.3439	8.6084	9.0097	10.4513	12.1298

Period 6

55	56		72	73	74	75	76	77	78	79	80	81	82	83	84	85	86
$^2S_{1/2}$	$^1S_0$		$^3F_2$	$^4F_{3/2}$	$^5D_0$	$^6S_{5/2}$	$^5D_4$	$^4F_{9/2}$	$^3D_3$	$^2S_{1/2}$	$^1S_0$	$^2P^o_{1/2}$	$^3P_0$	$^4S^o_{3/2}$	$^3P_2$	$^2P^o_{3/2}$	$^1S_0$
Cs	**Ba**		**Hf**	**Ta**	**W**	**Re**	**Os**	**Ir**	**Pt**	**Au**	**Hg**	**Tl**	**Pb**	**Bi**	**Po**	**At**	**Rn**
Cesium	Barium		Hafnium	Tantalum	Tungsten	Rhenium	Osmium	Iridium	Platinum	Gold	Mercury	Thallium	Lead	Bismuth	Polonium	Astatine	Radon
132.9054520*	137.327		178.49	180.94788	183.84	186.207	190.23	192.217	195.084	196.966569	200.592	204.38*	207.2	208.98040	(209)	(210)	(222)
$[Xe]6s$	$[Xe]6s^2$		$[Xe]4f^{14}5d^26s^2$	$[Xe]4f^{14}5d^36s^2$	$[Xe]4f^{14}5d^46s^2$	$[Xe]4f^{14}5d^56s^2$	$[Xe]4f^{14}5d^66s^2$	$[Xe]4f^{14}5d^76s^2$	$[Xe]4f^{14}5d^96s$	$[Xe]4f^{14}5d^{10}6s$	$[Hg]6p$	$[Hg]6p^2$	$[Hg]6p^3$	$[Hg]6p^4$	$[Hg]6p^5$	$[Hg]6p^6$	
3.8939	5.2117		6.8251	7.5496	7.8640	7.8335	8.4382	8.9670	8.9588	9.2256	10.4375	6.1083	7.4167	7.2855	8.414	9.3175	10.7485

Period 7

87	88		104	105	106	107	108	109	110	111	112	113	114	115	116	117	118
$^2S_{1/2}$	$^1S_0$		$^3F_2$	$^4F_{3/2}$	$^5D_0$	$^6S_{5/2}$	$^5D_4$	$^4F_{9/2}$	$^3D_3$	$^2S_{1/2}$	$^1S_0$	$^2P^o_{1/2}$	$^3P_0$	$^4S^o_{3/2}$	$^3P_2$	$^2P^o_{3/2}$	$^1S_0$
Fr	**Ra**		**Rf**	**Db**	**Sg**	**Bh**	**Hs**	**Mt**	**Ds**	**Rg**	**Cn**	**Nh**	**Fl**	**Mc**	**Lv**	**Ts**	**Og**
Francium	Radium		Rutherfordium	Dubnium	Seaborgium	Bohrium	Hassium	Meitnerium	Darmstadtium	Roentgenium	Copernicium	Nihonium	Flerovium	Moscovium	Livermorium	Tennessine	Oganesson
(223)	(226)		(267)	(268)	(271)	(270)	(269)	(278)	(281)	(282)	(285)	(286)	(289)	(289)	(293)	(294)	(294)
$[Rn]7s$	$[Rn]7s^2$		$[Rn]5f^{14}6d^27s^2$	$[Rn]5f^{14}6d^37s^2$	$[Rn]5f^{14}6d^47s^2$	$[Rn]5f^{14}6d^57s^2$	$[Rn]5f^{14}6d^67s^2$										
4.0727	5.2784		6.01	6.8	7.8	7.7	7.6										

Lanthanides	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71
	$^2D_{3/2}$	$^1G^o_4$	$^4I^o_{9/2}$	$^5I_4$	$^6H^o_{5/2}$	$^7F_0$	$^8S^o_{7/2}$	$^9D^o_2$	$^6H^o_{15/2}$	$^5I_8$	$^4I^o_{15/2}$	$^3H_6$	$^2F^o_{7/2}$	$^1S_0$	$^2D_{3/2}$
	La	**Ce**	**Pr**	**Nd**	**Pm**	**Sm**	**Eu**	**Gd**	**Tb**	**Dy**	**Ho**	**Er**	**Tm**	**Yb**	**Lu**
	Lanthanum	Cerium	Praseodymium	Neodymium	Promethium	Samarium	Europium	Gadolinium	Terbium	Dysprosium	Holmium	Erbium	Thulium	Ytterbium	Lutetium
	138.90547	140.116	140.90766	144.242	(145)	150.36	151.964	157.25	158.92535	162.500	164.93033	167.259	168.93422	173.045	174.9668
	$[Xe]5d6s^2$	$[Xe]4f5d6s^2$	$[Xe]4f^36s^2$	$[Xe]4f^46s^2$	$[Xe]4f^56s^2$	$[Xe]4f^66s^2$	$[Xe]4f^76s^2$	$[Xe]4f^75d6s^2$	$[Xe]4f^96s^2$	$[Xe]4f^{10}6s^2$	$[Xe]4f^{11}6s^2$	$[Xe]4f^{12}6s^2$	$[Xe]4f^{13}6s^2$	$[Xe]4f^{14}6s^2$	$[Xe]4f^{14}5d6s^2$
	5.5769	5.5386	5.473	5.5250	5.582	5.6437	5.6704	6.1498	5.8638	5.9391	6.0215	6.1077	6.1843	6.2542	5.4259
Actinides	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103
	$^2D_{3/2}$	$^3F_2$	$^4K_{11/2}$	$^5L^o_6$	$^6L_{11/2}$	$^7F_0$	$^8S^o_{7/2}$	$^9D^o_2$	$^6H^o_{15/2}$	$^5I_8$	$^4I^o_{15/2}$	$^3H_6$	$^2F^o_{7/2}$	$^1S_0$	$^2P^o_{1/2}$
	Ac	**Th**	**Pa**	**U**	**Np**	**Pu**	**Am**	**Cm**	**Bk**	**Cf**	**Es**	**Fm**	**Md**	**No**	**Lr**
	Actinium	Thorium	Protactinium	Uranium	Neptunium	Plutonium	Americium	Curium	Berkelium	Californium	Einsteinium	Fermium	Mendelevium	Nobelium	Lawrencium
	(227)	232.0377	231.03588	238.02891	(237)	(244)	(243)	(247)	(247)	(251)	(252)	(257)	(258)	(259)	(266)
	$[Rn]6d7s^2$	$[Rn]6d^27s^2$	$[Rn]5f^26d7s^2$	$[Rn]5f^36d7s^2$	$[Rn]5f^46d7s^2$	$[Rn]5f^67s^2$	$[Rn]5f^77s^2$	$[Rn]5f^76d7s^2$	$[Rn]5f^97s^2$	$[Rn]5f^{10}7s^2$	$[Rn]5f^{11}7s^2$	$[Rn]5f^{12}7s^2$	$[Rn]5f^{13}7s^2$	$[Rn]5f^{14}7s^2$	$[Rn]5f^{14}7s^27p$
	5.3802	6.3067	5.89	6.1941	6.2655	6.0258	5.9738	5.9914	6.1978	6.2817	6.3676	6.50	6.58	6.65	4.96

Atomic Number | Ground-state Level
Symbol
Name
Standard Atomic Weight† (Da)
Ground-state Configuration | Ionization Energy (eV)

58 $^1G^o_4$
Ce
Cerium
140.116
$[Xe]4f5d6s^2$
5.5386

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

*For the most precise value, visit ciaaw.org.

For a description of the data, visit pml.nist.gov/data

NIST SP 966 (February 2017)

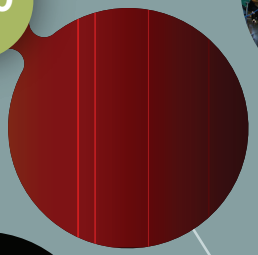
NISTory of the Periodic Table

Krypton:

Wavelengths of light from this atom, measured by NIST researchers, defined the official meter until 1983.

Image Credit: Neil Tucker/Wikimedia

1960

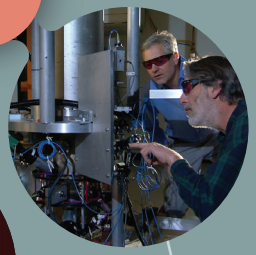


Cesium:

The frequency of microwave radiation from this atom is used to define the second, measured in atomic clocks such as the NIST-F2 (2014).

Image Credit: NIST

1967

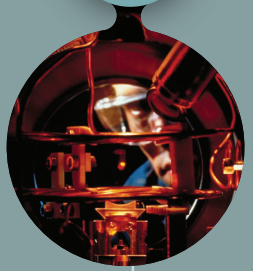


Sodium:

NIST scientists used lasers to cool a gas of these atoms to lower-than-predicted temperatures near absolute zero. (Nobel Prize 1997)

Image Credit: H.Mark Helfer/NIST

1988

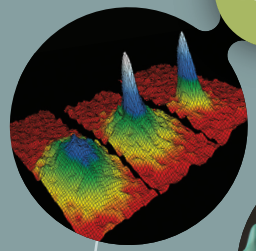


Rubidium:

The atoms that created the first Bose-Einstein condensate, made by researchers at JILA (NIST-University of Colorado). (Nobel Prize 2001)

Image Credit: NIST/JILA/CU-Boulder

1995

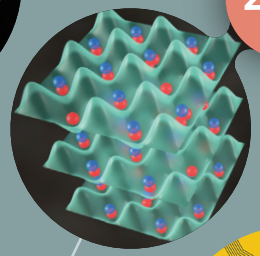


Potassium and Rubidium:

JILA researchers married these elements into an ultracold gas of molecules and demonstrated striking predictions of quantum physics by hitting the atoms with "rulers of light" known as frequency combs (Nobel Prize 2005) and trapping them in webs of light known as optical lattices.

Image Credit: Steven Burrows and Ye/Jin groups/JILA

2008

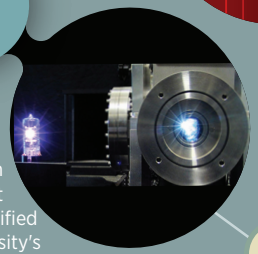


Deuterium:

This rare heavy isotope of hydrogen was concentrated at NIST and then identified by Columbia University's Harold Urey (Nobel Prize 1934). On the left is a deuterium lamp; the light on the right comes from the NIST SURF III Synchrotron Ultraviolet Radiation Facility.

Image Credit: Uwe Arp/NIST

1931

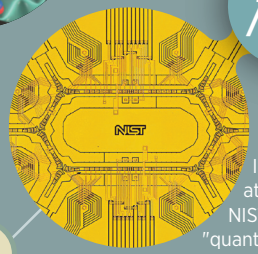


Beryllium and Aluminum:

Individual ions of these atoms were probed in a NIST trap to create "quantum logic" clocks that measured the second more precisely than before and tested Einstein's general theory of relativity. Such quantum manipulations were recognized in the 2012 Nobel Prize.

Image Credit: J. Amini/NIST

2010 /2011



National Institute of Standards and Technology
U.S. Department of Commerce
www.nist.gov

Design by: Natasha Hanacek/NIST