

PERIODIC TABLE Atomic Properties of the Elements

Group	1 IA	2 IIA	FREQUENTLY USED FUNDAMENTAL PHYSICAL CONSTANTS [§]										Physical Measurement Laboratory www.nist.gov/pml						2 VIII A						
Period	1 H Hydrogen 1.008 1s 13.5984		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 <i>c</i> 299 792 458 m s ⁻¹ (exact) Planck constant <i>h</i> 6.626 070 x 10 ⁻³⁴ J s elementary charge <i>e</i> 1.602 177 x 10 ⁻¹⁹ C electron mass <i>m_e</i> 9.109 384 x 10 ⁻³¹ kg <i>m_ec²</i> 0.510 999 MeV proton mass <i>m_p</i> 1.672 622 x 10 ⁻²⁷ kg fine-structure constant <i>α</i> 1/137.035 999 Rydberg constant <i>R_∞</i> 10 973 731.569 m ⁻¹ <i>R_∞c</i> 3.289 841 960 x 10 ¹⁵ Hz <i>R_∞hc</i> 13.605 693 eV electron volt eV 1.602 177 x 10 ⁻¹⁹ J Boltzmann constant <i>k</i> 1.380 65 x 10 ⁻²³ J K ⁻¹ molar gas constant <i>R</i> 8.314 5 J mol ⁻¹ K ⁻¹										§ For the most accurate values of these and other constants, visit pml.nist.gov/constants .												
Group	3 IIIB	4 IVB	5 VB	6 VIB	7 VIIB	VIII			10 IIB	11 IB	12 IIB	13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIII A								
2	Li Lithium 6.94 1s ² 2s	Be Beryllium 9.0122 1s ² 2s ²										B Boron 10.81 1s ² 2s ² 2p	C Carbon 12.011 1s ² 2s ² 2p ²	N Nitrogen 14.007 1s ² 2s ² 2p ³	O Oxygen 15.999 1s ² 2s ² 2p ⁴	F Fluorine 18.998 1s ² 2s ² 2p ⁵	Ne Neon 20.180 1s ² 2s ² 2p ⁶								
3	Na Sodium 22.990 [Ne]3s	Mg Magnesium 24.305 [Ne]3s ²										Al Aluminum 26.982 [Ne]3s ² 3p	Si Silicon 28.085 [Ne]3s ² 3p ²	P Phosphorus 30.974 [Ne]3s ² 3p ³	S Sulfur 32.06 [Ne]3s ² 3p ⁴	Cl Chlorine 35.45 [Ne]3s ² 3p ⁵	Ar Argon 39.948 [Ne]3s ² 3p ⁶								
4	K Potassium 39.098 [Ar]4s	Ca Calcium 40.078 [Ar]4s ²	Sc Scandium 44.956 [Ar]3d ¹ 4s ²	Ti Titanium 47.867 [Ar]3d ² 4s ²	V Vanadium 50.942 [Ar]3d ³ 4s ²	Cr Chromium 51.996 [Ar]3d ⁵ 4s	Mn Manganese 54.938 [Ar]3d ⁵ 4s ²	Fe Iron 55.845 [Ar]3d ⁶ 4s ²	Co Cobalt 58.933 [Ar]3d ⁷ 4s ²	Ni Nickel 58.693 [Ar]3d ⁸ 4s ²	Cu Copper 63.546 [Ar]3d ¹⁰ 4s	Zn Zinc 65.38 [Ar]3d ¹⁰ 4s ²	Ga Gallium 69.723 [Ar]3d ¹⁰ 4s ² 4p	Ge Germanium 72.630 [Ar]3d ¹⁰ 4s ² 4p ²	As Arsenic 74.922 [Ar]3d ¹⁰ 4s ² 4p ³	Se Selenium 78.971 [Ar]3d ¹⁰ 4s ² 4p ⁴	Br Bromine 79.904 [Ar]3d ¹⁰ 4s ² 4p ⁵	Kr Krypton 83.798 [Ar]3d ¹⁰ 4s ² 4p ⁶							
5	Rb Rubidium 85.468 [Kr]5s	Sr Strontium 87.62 [Kr]5s ²	Y Yttrium 88.906 [Kr]4d ⁵ 5s ²	Zr Zirconium 91.224 [Kr]4d ⁵ 5s ²	Nb Niobium 92.906 [Kr]4d ⁴ 5s	Mo Molybdenum 95.95 [Kr]4d ⁵ 5s	Tc Technetium (98) [Kr]4d ⁵ 5s ²	Ru Ruthenium 101.07 [Kr]4d ⁷ 5s	Rh Rhodium 102.91 [Kr]4d ⁸ 5s	Pd Palladium 106.42 [Kr]4d ¹⁰	Ag Silver 107.87 [Kr]4d ¹⁰ 5s	Cd Cadmium 112.41 [Kr]4d ¹⁰ 5s ²	In Indium 114.82 [Kr]4d ¹⁰ 5s ² 5p	Sn Tin 118.71 [Kr]4d ¹⁰ 5s ² 5p ²	Sb Antimony 121.76 [Kr]4d ¹⁰ 5s ² 5p ³	Te Tellurium 127.60 [Kr]4d ¹⁰ 5s ² 5p ⁴	I Iodine 126.90 [Kr]4d ¹⁰ 5s ² 5p ⁵	Xe Xenon 131.29 [Kr]4d ¹⁰ 5s ² 5p ⁶							
6	Cs Cesium 132.91 [Xe]6s	Ba Barium 137.33 [Xe]6s ²		Hf Hafnium 178.49 [Xe]4f ¹⁴ 5d ⁴ 6s ²	Ta Tantalum 180.95 [Xe]4f ¹⁴ 5d ³ 6s ²	W Tungsten 183.84 [Xe]4f ¹⁴ 5d ⁴ 6s ²	Re Rhenium 186.21 [Xe]4f ¹⁴ 5d ⁵ 6s ²	Os Osmium 190.23 [Xe]4f ¹⁴ 5d ⁶ 6s ²	Ir Iridium 192.22 [Xe]4f ¹⁴ 5d ⁷ 6s ²	Pt Platinum 195.08 [Xe]4f ¹⁴ 5d ⁹ 6s ¹	Au Gold 196.97 [Xe]4f ¹⁴ 5d ¹⁰ 6s ¹	Hg Mercury 200.59 [Xe]4f ¹⁴ 5d ¹⁰ 6s ²	Tl Thallium 204.38 [Hg]6p	Pb Lead 207.2 [Hg]6p ²	Bi Bismuth 208.98 [Hg]6p ³	Po Polonium (209) [Hg]6p ⁴	At Astatine (210) [Hg]6p ⁵	Rn Radon (222) [Hg]6p ⁶							
7	Fr Francium (223) [Rn]7s	Ra Radium (226) [Rn]7s ²		Rf Rutherfordium (268) [Rn]5f ¹⁴ 6d ² 7s ²	Db Dubnium (269) [Rn]5f ¹⁴ 6d ³ 7s ²	Sg Seaborgium (271) [Rn]5f ¹⁴ 6d ⁴ 7s ²	Bh Bohrium (270) [Rn]5f ¹⁴ 6d ⁵ 7s ²	Hs Hassium (269) [Rn]5f ¹⁴ 6d ⁶ 7s ²	Mt Meitnerium (278)	Ds Darmstadtium (281)	Rg Roentgenium (282)	Cn Copernicium (285)	Nh Nihonium (286)	Fl Flerovium (289)	Mc Moscovium (289)	Lv Livermorium (293)	Ts Tennessine (294)	Og Oganesson (294)							
			Lanthanides				57 ² D _{3/2} La Lanthanum 138.91 [Xe]5d ¹ 6s ²	58 ¹ G ₄ Ce Cerium 140.116 [Xe]4f ¹ 5d ¹ 6s ²	59 ⁴ I _{9/2} Pr Praseodymium 140.91 [Xe]4f ³ 6s ²	60 ⁵ I ₄ Nd Neodymium 144.24 [Xe]4f ⁴ 6s ²	61 ⁶ H _{5/2} Pm Promethium (145) [Xe]4f ⁵ 6s ²	62 ⁷ F ₀ Sm Samarium 150.36 [Xe]4f ⁶ 6s ²	63 ⁸ S _{7/2} Eu Europium 151.96 [Xe]4f ⁷ 6s ²	64 ⁹ D ₂ Gd Gadolinium 157.25 [Xe]4f ⁷ 5d ¹ 6s ²	65 ⁶ H _{15/2} Tb Terbium 158.93 [Xe]4f ⁹ 6s ²	66 ⁵ I ₈ Dy Dysprosium 162.50 [Xe]4f ¹⁰ 6s ²	67 ⁴ I _{15/2} Ho Holmium 164.93 [Xe]4f ¹¹ 6s ²	68 ³ H ₆ Er Erbium 167.26 [Xe]4f ¹² 6s ²	69 ² F _{7/2} Tm Thulium 168.93 [Xe]4f ¹³ 6s ²	70 ¹ S ₀ Yb Ytterbium 173.05 [Xe]4f ¹⁴ 6s ²	71 ² D _{3/2} Lu Lutetium 174.97 [Xe]4f ¹⁴ 5d ¹ 6s ²				
			Actinides				89 ² D _{3/2} Ac Actinium (227) [Rn]6d ¹ 7s ²	90 ³ F ₂ Th Thorium 232.04 [Rn]6d ² 7s ²	91 ⁴ K _{11/2} Pa Protactinium 231.04 [Rn]5f ¹ 6d ¹ 7s ²	92 ⁵ L ₆ U Uranium 238.03 [Rn]5f ³ 6d ¹ 7s ²	93 ⁶ L _{11/2} Np Neptunium (237) [Rn]5f ⁴ 6d ¹ 7s ²	94 ⁷ F ₀ Pu Plutonium (244) [Rn]5f ⁶ 7s ²	95 ⁸ S _{7/2} Am Americium (243) [Rn]5f ⁷ 7s ²	96 ⁹ D ₂ Cm Curium (247) [Rn]5f ⁷ 6d ¹ 7s ²	97 ⁶ H _{15/2} Bk Berkelium (247) [Rn]5f ⁹ 7s ²	98 ⁵ I ₈ Cf Californium (251) [Rn]5f ¹⁰ 7s ²	99 ⁴ I _{15/2} Es Einsteinium (252) [Rn]5f ¹¹ 7s ²	100 ³ H ₆ Fm Fermium (257) [Rn]5f ¹² 7s ²	101 ² F _{7/2} Md Mendelevium (288) [Rn]5f ¹³ 7s ²	102 ¹ S ₀ No Nobelium (259) [Rn]5f ¹⁴ 7s ²	103 ² P _{1/2} Lr Lawrencium (260) [Rn]5f ¹⁴ 7s ² 7p				

[†]Based upon ¹²C. () indicates the mass number of the longest-lived isotope.

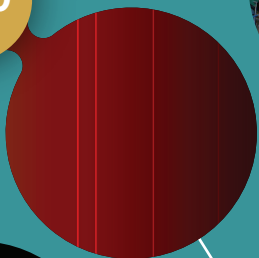
NISTory of the Periodic Table

Krypton:

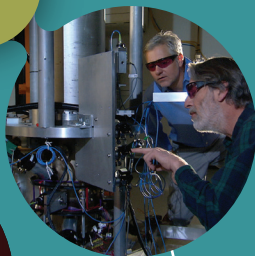
Wavelengths of light from this atom, measured by NIST researchers, defined the official meter until 1983.

Image Credit: Neil Tucker/Wikimedia

1960



1967

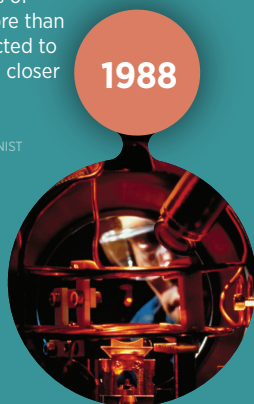


Sodium:

NIST scientists used lasers to cool a gas of these atoms to more than theoretically expected to temperatures even closer to absolute zero. (Nobel Prize 1997)

Image Credit: H.Mark Hefner/NIST

1988

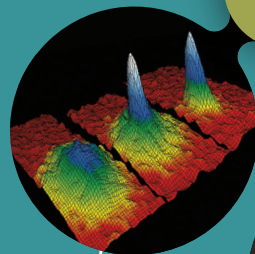


Rubidium:

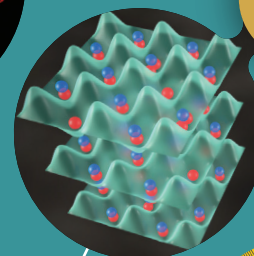
These atoms were used by researchers at JILA (NIST-CU Boulder) to create the first Bose-Einstein condensate (Nobel Prize 2001).

Image Credit: NIST/JILA/CU-Boulder

1995



2008

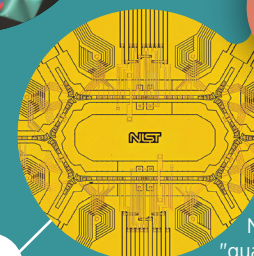


Potassium and Rubidium:

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

2010/2011



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

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

