CODATA RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS: 2006

NIST SP 961 (Aug/2008) Values from: P. J. Mohr, B. N. Taylor, and D. B. Newell, Rev. Mod. Phys. **80**, 633 (2008) and J. Phys. Chem. Ref. Data **37**, 1187 (2008).

A more extensive listing of constants is available in the above references and on the NIST Physics Laboratory Web site physics.nist.gov/constants.

The number in parentheses is the one-standard-deviation uncertainty in the last two digits of the given value.

Quantity	Symbol	Numerical value	Unit
speed of light in vacuum	c, c_0	299 792 458 (exact)	m s^{-1}
magnetic constant	μ_0	$4\pi \times 10^{-7}$ (exact)	N A^{-2}
		= 12.566 370 614... × 10^{-7}	N A^{-2}
electric constant $1/\mu_0 c^2$	ϵ_0	8.854 187 817... × 10^{-12}	F m^{-1}
Newtonian constant of gravitation	G	6.674 28(67) × 10^{-11}	m^3 kg^{-1} s^{-2}
Planck constant	h	6.626 068 96(33) × 10^{-34}	J s
in eV s		4.135 667 33(10) × 10^{-15}	eV s
$h/2\pi$	$\hbar$	1.054 571 628(53) × 10^{-34}	J s
in eV s		6.582 118 99(16) × 10^{-16}	eV s
elementary charge	e	1.602 176 487(40) × 10^{-19}	C
magnetic flux quantum $h/2e$	Φ_0	2.067 833 667(52) × 10^{-15}	Wb
Josephson constant $2e/h$	K_J	483 597.891(12) × 10^{9}	Hz V^{-1}
von Klitzing constant $h/e^2 = \mu_0 c/2\alpha$	R_K	25 812.807 557(18)	Ω
Bohr magneton $e\hbar/2m_e$	μ_B	927.400 915(23) × 10^{-26}	J T^{-1}
in eV T^{-1}		5.788 381 7555(79) × 10^{-5}	eV T^{-1}
nuclear magneton $e\hbar/2m_p$	μ_N	5.050 783 24(13) × 10^{-27}	J T^{-1}
in eV T^{-1}		3.152 451 2326(45) × 10^{-8}	eV T^{-1}
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	α	7.297 352 5376(50) × 10^{-3}	
inverse fine-structure constant	α^{-1}	137.035 999 679(94)	
Rydberg constant $\alpha^2 m_e c/2h$	R_∞	10 973 731.568 527(73)	m^{-1}
	$R_\infty c$	3.289 841 960 361(22) × 10^{15}	Hz
energy equivalent in eV	$R_\infty hc$	13.605 691 93(34)	eV
Bohr radius $\alpha/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2$	a_0	0.529 177 208 59(36) × 10^{-10}	m
Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2R_\infty hc = \alpha^2 m_e c^2$	E_h	4.359 743 94(22) × 10^{-18}	J
in eV		27.211 383 86(68)	eV
electron mass	m_e	9.109 382 15(45) × 10^{-31}	kg
in u		5.485 799 0943(23) × 10^{-4}	u
energy equivalent in MeV	$m_e c^2$	0.510 998 910(13)	MeV
electron-muon mass ratio	m_e/m_μ	4.836 331 71(12) × 10^{-3}	
electron-proton mass ratio	m_e/m_p	5.446 170 2177(24) × 10^{-4}	
electron charge to mass quotient	$-e/m_e$	−1.758 820 150(44) × 10^{11}	C kg^{-1}
Compton wavelength $h/m_e c$	λ_C	2.426 310 2175(33) × 10^{-12}	m
$\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\bar{\lambda}_C$	386.159 264 59(53) × 10^{-15}	m
classical electron radius $\alpha^2 a_0$	r_e	2.817 940 2894(58) × 10^{-15}	m
Thomson cross section $(8\pi/3)r_e^2$	σ_e	0.665 245 8558(27) × 10^{-28}	m^2
electron magnetic moment	μ_e	−928.476 377(23) × 10^{-26}	J T^{-1}
to Bohr magneton ratio	μ_e/μ_B	−1.001 159 652 181 11(74)	
to nuclear magneton ratio	μ_e/μ_N	−1838.281 970 92(80)	
electron magnetic moment anomaly $\lvert\mu_e\rvert/\mu_B - 1$	a_e	1.159 652 181 11(74) × 10^{-3}	
electron g-factor $-2(1+a_e)$	g_e	−2.002 319 304 3622(15)	
electron-proton magnetic moment ratio	μ_e/μ_p	−658.210 6848(54)	
muon mass in u	m_μ	0.113 428 9256(29)	u
energy equivalent in MeV	$m_\mu c^2$	105.658 3668(38)	MeV
muon-electron mass ratio	m_μ/m_e	206.768 2823(52)	
muon magnetic moment	μ_μ	−4.490 447 86(16) × 10^{-26}	J T^{-1}
to Bohr magneton ratio	μ_μ/μ_B	−4.841 970 49(12) × 10^{-3}	
to nuclear magneton ratio	μ_μ/μ_N	−8.890 597 05(23)	
muon magnetic moment anomaly $\lvert\mu_\mu\rvert/(e\hbar/2m_\mu) - 1$	a_μ	1.165 920 69(60) × 10^{-3}	

Quantity	Symbol	Numerical value	Unit
muon g-factor $-2(1+a_\mu)$	g_μ	−2.002 331 8414(12)	
muon-proton magnetic moment ratio	μ_μ/μ_p	−3.183 345 137(85)	
proton mass	m_p	1.672 621 637(83) × 10^{-27}	kg
in u		1.007 276 466 77(10)	u
energy equivalent in MeV	$m_p c^2$	938.272 013(23)	MeV
proton-electron mass ratio	m_p/m_e	1836.152 672 47(80)	
proton magnetic moment	μ_p	1.410 606 662(37) × 10^{-26}	J T^{-1}
to nuclear magneton ratio	μ_p/μ_N	2.792 847 356(23)	
proton magnetic shielding correction $1 - \mu'_p/\mu_p$ (H_2O, sphere, 25 °C)	σ'_p	25.694(14) × 10^{-6}	
proton gyromagnetic ratio $2\mu_p/\hbar$	γ_p	2.675 222 099(70) × 10^{8}	s^{-1} T^{-1}
	$\gamma_p/2\pi$	42.577 4821(11)	MHz T^{-1}
shielded proton gyromagnetic ratio $2\mu'_p/\hbar$ (H_2O, sphere, 25 °C)	γ'_p	2.675 153 362(73) × 10^{8}	s^{-1} T^{-1}
	$\gamma'_p/2\pi$	42.576 3881(12)	MHz T^{-1}
neutron mass in u	m_n	1.008 664 915 97(43)	u
energy equivalent in MeV	$m_n c^2$	939.565 346(23)	MeV
neutron-proton mass ratio	m_n/m_p	1.001 378 419 18(46)	
neutron magnetic moment	μ_n	−0.966 236 41(23) × 10^{-26}	J T^{-1}
to nuclear magneton ratio	μ_n/μ_N	−1.913 042 73(45)	
deuteron mass in u	m_d	2.013 553 212 724(78)	u
energy equivalent in MeV	$m_d c^2$	1875.612 793(47)	MeV
deuteron-proton mass ratio	m_d/m_p	1.999 007 501 08(22)	
deuteron magnetic moment	μ_d	0.433 073 465(11) × 10^{-26}	J T^{-1}
to nuclear magneton ratio	μ_d/μ_N	0.857 438 2308(72)	
helion (^{3}He nucleus) mass in u	m_h	3.014 932 2473(26)	u
energy equivalent in MeV	$m_h c^2$	2808.391 383(70)	MeV
shielded helion magnetic moment (gas, sphere, 25 °C)	μ'_h	−1.074 552 982(30) × 10^{-26}	J T^{-1}
to Bohr magneton ratio	μ'_h/μ_B	−1.158 671 471(14) × 10^{-3}	
to nuclear magneton ratio	μ'_h/μ_N	−2.127 497 718(25)	
alpha particle mass in u	m_α	4.001 506 179 127(62)	u
energy equivalent in MeV	$m_\alpha c^2$	3727.379 109(93)	MeV
Avogadro constant	N_A, L	6.022 141 79(30) × 10^{23}	mol^{-1}
atomic mass constant $\frac{1}{12}m(^{12}C) = 1$ u	m_u	1.660 538 782(83) × 10^{-27}	kg
energy equivalent in MeV	$m_u c^2$	931.494 028(23)	MeV
Faraday constant $N_A e$	F	96 485.3399(24)	C mol^{-1}
molar gas constant	R	8.314 472(15)	J mol^{-1} K^{-1}
Boltzmann constant R/N_A	k	1.380 6504(24) × 10^{-23}	J K^{-1}
in eV K^{-1}		8.617 343(15) × 10^{-5}	eV K^{-1}
molar volume of ideal gas RT/p ($T = 273.15$ K, $p = 101.325$ kPa)	V_m	22.413 996(39) × 10^{-3}	m^3 mol^{-1}
Stefan-Boltzmann constant $\pi^2 k^4/60\hbar^3 c^2$	σ	5.670 400(40) × 10^{-8}	W m^{-2} K^{-4}
first radiation constant $2\pi hc^2$	c_1	3.741 771 18(19) × 10^{-16}	W m^2
second radiation constant hc/k	c_2	1.438 7752(25) × 10^{-2}	m K
Wien displacement law constant $b = \lambda_{max}T = c_2/4.965\,114\,231...$	b	2.897 7685(51) × 10^{-3}	m K
Cu x unit: $\lambda(\mathrm{Cu\,K\alpha_1})/1\,537.400$	xu(Cu $K\alpha_1$)	1.002 076 99(28) × 10^{-13}	m
Mo x unit: $\lambda(\mathrm{Mo\,K\alpha_1})/707.831$	xu(Mo $K\alpha_1$)	1.002 099 55(53) × 10^{-13}	m

Energy equivalents

(1 m^{-1})c = 299 792 458 Hz	(1 Hz)h/k = 4.799 2374(84) × 10^{-11} K	(1 J) = 6.241 509 65(16) × 10^{18} eV	(1 eV)/c^2 = 1.073 544 188(27) × 10^{-9} u
(1 m^{-1})hc/k = 1.438 7752(25) × 10^{-2} K	(1 Hz)h = 4.135 667 33(10) × 10^{-15} eV	(1 eV) = 1.602 176 487(40) × 10^{-19} J	(1 kg) = 6.022 141 79(30) × 10^{26} u
(1 m^{-1})hc = 1.239 841 875(31) × 10^{-6} eV	(1 K)k/hc = 69.503 56(12) m^{-1}	(1 eV)/hc = 8.065 544 65(20) × 10^{5} m^{-1}	(1 u) = 1.660 538 782(83) × 10^{-27} kg
(1 m^{-1})h/c = 1.331 025 0394(19) × 10^{-15} u	(1 K)k/h = 2.083 6644(36) × 10^{10} Hz	(1 eV)/h = 2.417 989 454(60) × 10^{14} Hz	(1 u)c/h = 7.513 006 671(11) × 10^{14} m^{-1}
(1 Hz)/c = 3.335 640 951 . . . × 10^{-9} m^{-1}	(1 K)k = 8.617 343(15) × 10^{-5} eV	(1 eV)/k = 1.160 4505(20) × 10^{4} K	(1 u)c^2 = 931.494 028(23) × 10^{6} eV