CODATA RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS: 2010

NIST SP 961 (Dec/2012) Values from: P. J. Mohr, B. N. Taylor, and D. B. Newell, Rev. Mod. Phys. **84**, 1527 (2012) and J. Phys. Chem. Ref. Data **41**, 043109 (2012).

A more extensive listing of constants is available in the above references and on the NIST Physical Measurement 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}
		$= 12.566\,370\,614... \times 10^{-7}$	N A^{-2}
electric constant $1/\mu_0 c^2$	ϵ_0	$8.854\,187\,817... \times 10^{-12}$	F m^{-1}
Newtonian constant of gravitation	G	$6.673\,84(80) \times 10^{-11}$	m^3 kg^{-1} s^{-2}
Planck constant	h	$6.626\,069\,57(29) \times 10^{-34}$	J s
in eV s		$4.135\,667\,516(91) \times 10^{-15}$	eV s
$h/2\pi$	$\hbar$	$1.054\,571\,726(47) \times 10^{-34}$	J s
in eV s		$6.582\,119\,28(15) \times 10^{-16}$	eV s
elementary charge	e	$1.602\,176\,565(35) \times 10^{-19}$	C
magnetic flux quantum $h/2e$	Φ_0	$2.067\,833\,758(46) \times 10^{-15}$	Wb
Josephson constant $2e/h$	$K_{\rm J}$	$483\,597.870(11) \times 10^{9}$	Hz V^{-1}
von Klitzing constant $h/e^2 = \mu_0 c/2\alpha$	$R_{\rm K}$	25 812.807 4434(84)	Ω
Bohr magneton $e\hbar/2m_{\rm e}$	$\mu_{\rm B}$	$927.400\,968(20) \times 10^{-26}$	J T^{-1}
in eV T^{-1}		$5.788\,381\,8066(38) \times 10^{-5}$	eV T^{-1}
nuclear magneton $e\hbar/2m_{\rm p}$	$\mu_{\rm N}$	$5.050\,783\,53(11) \times 10^{-27}$	J T^{-1}
in eV T^{-1}		$3.152\,451\,2605(22) \times 10^{-8}$	eV T^{-1}
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	α	$7.297\,352\,5698(24) \times 10^{-3}$	
inverse fine-structure constant	α^{-1}	137.035 999 074(44)	
Rydberg constant $\alpha^2 m_{\rm e}c/2h$	R_∞	10 973 731.568 539(55)	m^{-1}
	$R_\infty c$	$3.289\,841\,960\,364(17) \times 10^{15}$	Hz
energy equivalent in eV	$R_\infty hc$	13.605 692 53(30)	eV
Bohr radius $\alpha/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_{\rm e}e^2$	a_0	$0.529\,177\,210\,92(17) \times 10^{-10}$	m
Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2R_\infty hc = \alpha^2 m_{\rm e}c^2$	$E_{\rm h}$	$4.359\,744\,34(19) \times 10^{-18}$	J
in eV		27.211 385 05(60)	eV
electron mass	$m_{\rm e}$	$9.109\,382\,91(40) \times 10^{-31}$	kg
in u		$5.485\,799\,0946(22) \times 10^{-4}$	u
energy equivalent in MeV	$m_{\rm e}c^2$	0.510 998 928(11)	MeV
electron-muon mass ratio	$m_{\rm e}/m_\mu$	$4.836\,331\,66(12) \times 10^{-3}$	
electron-proton mass ratio	$m_{\rm e}/m_{\rm p}$	$5.446\,170\,2178(22) \times 10^{-4}$	
electron charge to mass quotient	$-e/m_{\rm e}$	$-1.758\,820\,088(39) \times 10^{11}$	C kg^{-1}
Compton wavelength $h/m_{\rm e}c$	$\lambda_{\rm C}$	$2.426\,310\,2389(16) \times 10^{-12}$	m
$\lambda_{\rm C}/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\bar{\lambda}_{\rm C}$	$386.159\,268\,00(25) \times 10^{-15}$	m
classical electron radius $\alpha^2 a_0$	$r_{\rm e}$	$2.817\,940\,3267(27) \times 10^{-15}$	m
Thomson cross section $(8\pi/3)r_{\rm e}^2$	$\sigma_{\rm e}$	$0.665\,245\,8734(13) \times 10^{-28}$	m^2
electron magnetic moment	$\mu_{\rm e}$	$-928.476\,430(21) \times 10^{-26}$	J T^{-1}
to Bohr magneton ratio	$\mu_{\rm e}/\mu_{\rm B}$	−1.001 159 652 180 76(27)	
to nuclear magneton ratio	$\mu_{\rm e}/\mu_{\rm N}$	−1838.281 970 90(75)	
electron magnetic moment anomaly $\lvert\mu_{\rm e}\rvert/\mu_{\rm B} - 1$	$a_{\rm e}$	$1.159\,652\,180\,76(27) \times 10^{-3}$	
electron g-factor $-2(1+a_{\rm e})$	$g_{\rm e}$	−2.002 319 304 361 53(53)	
electron-proton magnetic moment ratio	$\mu_{\rm e}/\mu_{\rm p}$	−658.210 6848(54)	
muon mass in u	m_μ	0.113 428 9267(29)	u
energy equivalent in MeV	$m_\mu c^2$	105.658 3715(35)	MeV
muon-electron mass ratio	$m_\mu/m_{\rm e}$	206.768 2843(52)	
muon magnetic moment	μ_μ	$-4.490\,448\,07(15) \times 10^{-26}$	J T^{-1}
to Bohr magneton ratio	$\mu_\mu/\mu_{\rm B}$	$-4.841\,970\,44(12) \times 10^{-3}$	
to nuclear magneton ratio	$\mu_\mu/\mu_{\rm N}$	−8.890 596 97(22)	
muon magnetic moment anomaly			
$\lvert\mu_\mu\rvert/(e\hbar/2m_\mu) - 1$	a_μ	$1.165\,920\,91(63) \times 10^{-3}$	
muon g-factor $-2(1+a_\mu)$	g_μ	−2.002 331 8418(13)	
muon-proton magnetic moment ratio	$\mu_\mu/\mu_{\rm p}$	−3.183 345 107(84)	
proton mass	$m_{\rm p}$	$1.672\,621\,777(74) \times 10^{-27}$	kg
in u		1.007 276 466 812(90)	u
energy equivalent in MeV	$m_{\rm p}c^2$	938.272 046(21)	MeV
proton-electron mass ratio	$m_{\rm p}/m_{\rm e}$	1836.152 672 45(75)	
proton magnetic moment	$\mu_{\rm p}$	$1.410\,606\,743(33) \times 10^{-26}$	J T^{-1}
to nuclear magneton ratio	$\mu_{\rm p}/\mu_{\rm N}$	2.792 847 356(23)	
proton magnetic shielding correction $1 - \mu'_{\rm p}/\mu_{\rm p}$ (H_2O, sphere, 25 °C)	$\sigma'_{\rm p}$	$25.694(14) \times 10^{-6}$	
proton gyromagnetic ratio $2\mu_{\rm p}/\hbar$	$\gamma_{\rm p}$	$2.675\,222\,005(63) \times 10^{8}$	s^{-1} T^{-1}
	$\gamma_{\rm p}/2\pi$	42.577 4806(10)	MHz T^{-1}
shielded proton gyromagnetic ratio $2\mu'_{\rm p}/\hbar$	$\gamma'_{\rm p}$	$2.675\,153\,268(66) \times 10^{8}$	s^{-1} T^{-1}
(H_2O, sphere, 25 °C)			
	$\gamma'_{\rm p}/2\pi$	42.576 3866(10)	MHz T^{-1}
neutron mass in u	$m_{\rm n}$	1.008 664 916 00(43)	u
energy equivalent in MeV	$m_{\rm n}c^2$	939.565 379(21)	MeV
neutron-proton mass ratio	$m_{\rm n}/m_{\rm p}$	1.001 378 419 17(45)	
neutron magnetic moment	$\mu_{\rm n}$	$-0.966\,236\,47(23) \times 10^{-26}$	J T^{-1}
to nuclear magneton ratio	$\mu_{\rm n}/\mu_{\rm N}$	−1.913 042 72(45)	
deuteron mass in u	$m_{\rm d}$	2.013 553 212 712(77)	u
energy equivalent in MeV	$m_{\rm d}c^2$	1875.612 859(41)	MeV
deuteron-proton mass ratio	$m_{\rm d}/m_{\rm p}$	1.999 007 500 97(18)	
deuteron magnetic moment	$\mu_{\rm d}$	$0.433\,073\,489(10) \times 10^{-26}$	J T^{-1}
to nuclear magneton ratio	$\mu_{\rm d}/\mu_{\rm N}$	0.857 438 2308(72)	
helion (^{3}He nucleus) mass in u	$m_{\rm h}$	3.014 932 2468(25)	u
energy equivalent in MeV	$m_{\rm h}c^2$	2808.391 482(62)	MeV
shielded helion magnetic moment	$\mu'_{\rm h}$	$-1.074\,553\,044(27) \times 10^{-26}$	J T^{-1}
(gas, sphere, 25 °C)			
to Bohr magneton ratio	$\mu'_{\rm h}/\mu_{\rm B}$	$-1.158\,671\,471(14) \times 10^{-3}$	
to nuclear magneton ratio	$\mu'_{\rm h}/\mu_{\rm N}$	−2.127 497 718(25)	
alpha particle mass in u	m_α	4.001 506 179 125(62)	u
energy equivalent in MeV	$m_\alpha c^2$	3727.379 240(82)	MeV
Avogadro constant	$N_{\rm A}, L$	$6.022\,141\,29(27) \times 10^{23}$	mol^{-1}
atomic mass constant $\frac{1}{12}m(^{12}{\rm C}) = 1$ u	$m_{\rm u}$	$1.660\,538\,921(73) \times 10^{-27}$	kg
energy equivalent in MeV	$m_{\rm u}c^2$	931.494 061(21)	MeV
Faraday constant $N_{\rm A}e$	F	96 485.3365(21)	C mol^{-1}
molar gas constant	R	8.314 4621(75)	J mol^{-1} K^{-1}
Boltzmann constant $R/N_{\rm A}$	k	$1.380\,6488(13) \times 10^{-23}$	J K^{-1}
in eV K^{-1}		$8.617\,3324(78) \times 10^{-5}$	eV K^{-1}
molar volume of ideal gas RT/p	$V_{\rm m}$	$22.413\,968(20) \times 10^{-3}$	m^3 mol^{-1}
($T = 273.15$ K, $p = 101.325$ kPa)			
Stefan-Boltzmann constant $\pi^2 k^4/60\hbar^3 c^2$	σ	$5.670\,373(21) \times 10^{-8}$	W m^{-2} K^{-4}
first radiation constant $2\pi hc^2$	c_1	$3.741\,771\,53(17) \times 10^{-16}$	W m^2
second radiation constant hc/k	c_2	$1.438\,7770(13) \times 10^{-2}$	m K
Wien displacement law constant			
$b = \lambda_{\rm max}T = c_2/4.965\,114\,231...$	b	$2.897\,7721(26) \times 10^{-3}$	m K
Cu x unit: $\lambda({\rm Cu\,K}\alpha_1)/1\,537.400$	xu(Cu Kα_1)	$1.002\,076\,97(28) \times 10^{-13}$	m
Mo x unit: $\lambda({\rm Mo\,K}\alpha_1)/707.831$	xu(Mo Kα_1)	$1.002\,099\,52(53) \times 10^{-13}$	m

Energy equivalents

$(1\ {\rm m}^{-1})c = 299\,792\,458$ Hz	$(1\ {\rm Hz})h/k = 4.799\,2434(44) \times 10^{-11}$ K	$(1\ {\rm J}) = 6.241\,509\,34(14) \times 10^{18}$ eV	$(1\ {\rm eV})/c^2 = 1.073\,544\,150(24) \times 10^{-9}$ u
$(1\ {\rm m}^{-1})hc/k = 1.438\,7770(13) \times 10^{-2}$ K	$(1\ {\rm Hz})h = 4.135\,667\,516(91) \times 10^{-15}$ eV	$(1\ {\rm eV}) = 1.602\,176\,565(35) \times 10^{-19}$ J	$(1\ {\rm kg}) = 6.022\,141\,29(27) \times 10^{26}$ u
$(1\ {\rm m}^{-1})hc = 1.239\,841\,930(27) \times 10^{-6}$ eV	$(1\ {\rm K})k/hc = 69.503\,476(63)$ m^{-1}	$(1\ {\rm eV})/hc = 8.065\,544\,29(18) \times 10^{5}$ m^{-1}	$(1\ {\rm u}) = 1.660\,538\,921(73) \times 10^{-27}$ kg
$(1\ {\rm m}^{-1})h/c = 1.331\,025\,051\,20(94) \times 10^{-15}$ u	$(1\ {\rm K})k/h = 2.083\,6618(19) \times 10^{10}$ Hz	$(1\ {\rm eV})/h = 2.417\,989\,348(53) \times 10^{14}$ Hz	$(1\ {\rm u})c/h = 7.513\,006\,6042(53) \times 10^{14}$ m^{-1}
$(1\ {\rm Hz})/c = 3.335\,640\,951\ldots \times 10^{-9}$ m^{-1}	$(1\ {\rm K})k = 8.617\,3324(78) \times 10^{-5}$ eV	$(1\ {\rm eV})/k = 1.160\,4519(11) \times 10^{4}$ K	$(1\ {\rm u})c^2 = 931.494\,061(21) \times 10^{6}$ eV