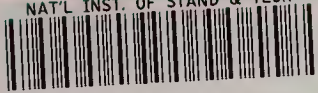


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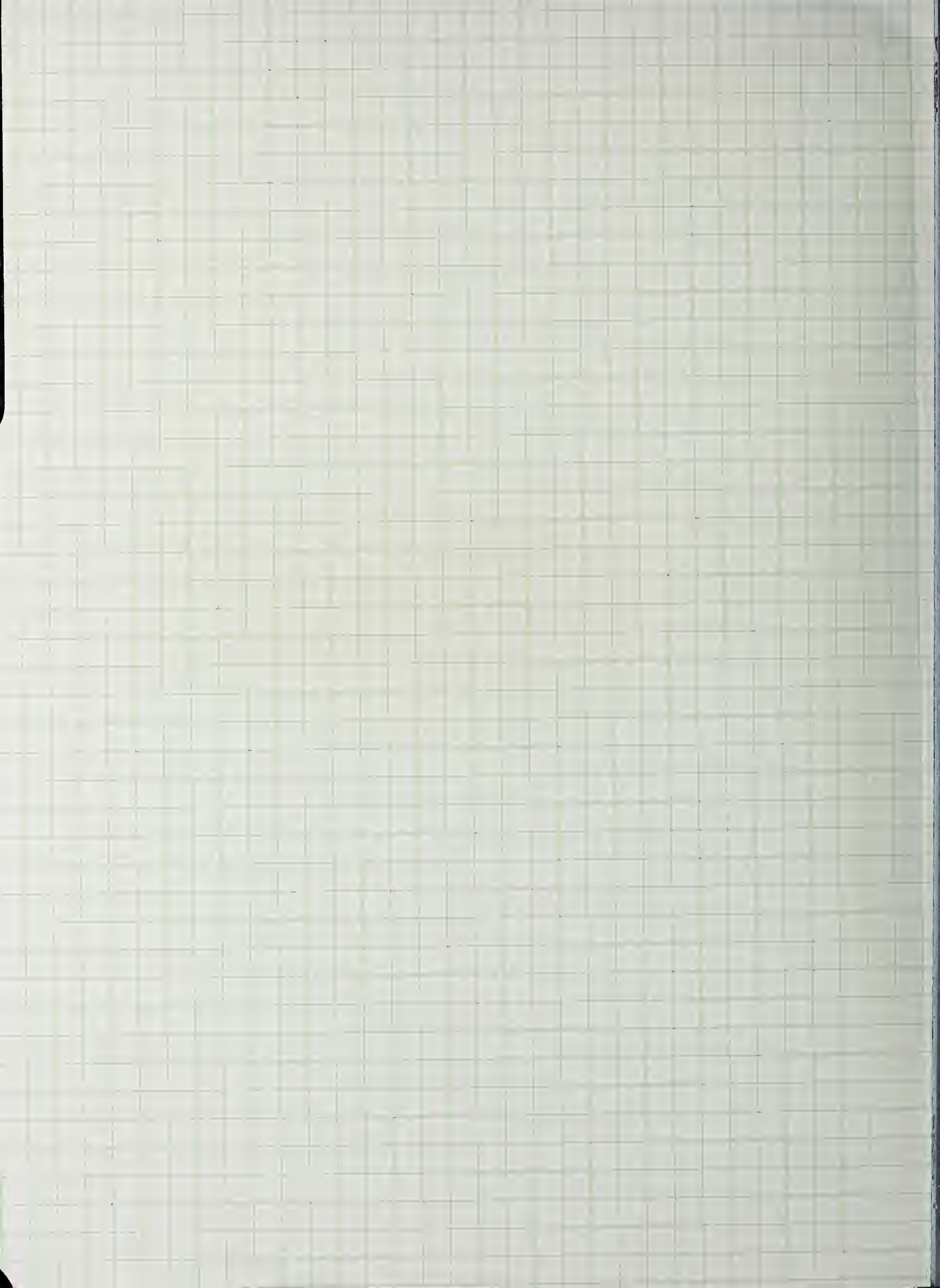


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1998 CODATA recommended values of the  
fundamental constants of physics and  
chemistry /  $\hbar c$  values from P.J. Mohr  
and B. N. Taylor.

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# 1998 CODATA RECOMMENDED VALUES OF THE FUNDAMENTAL CONSTANTS OF PHYSICS AND CHEMISTRY

NIST SP 961 (Jan/2001) Values from: P. J. Mohr and B. N. Taylor, *J. Phys. Chem. Ref. Data* **28**, 1713 (1999) and Rev. Mod. Phys. **72**, 351 (2000).

A more extensive listing of constants is available in the above references and on the NIST Physics Laboratory Web site [physics.nist.gov/constants](http://physics.nist.gov/constants). The number in parenthesis is the one-standard-deviation uncertainty in the last two digits of the given value.

Quantity	Symbol	Numerical value	Unit	Quantity	Symbol	Numerical value	Unit
speed of light in vacuum	$c$ , $c_0$	299 792 458 (exact)	m s <sup>-1</sup>	muon $g$ -factor $-2(1 + a_\mu)$	$g_\mu$	-2.002 331 8320(13)	
magnetic constant	$\mu_0$	$4\pi \times 10^{-7}$ (exact) = 12.566 370 614... $\times 10^{-7}$	N A <sup>-2</sup>	muon-proton magnetic moment ratio	$\mu_\mu/\mu_p$	-3.183 345 39(10)	kg
electric constant $1/\mu_0 c^2$	$\epsilon_0$	8.854 187 817... $\times 10^{-12}$	N A <sup>-2</sup>	proton mass	$m_p$	1.672 621 58(13) $\times 10^{-27}$	u
Newtonian constant of gravitation	$G$	6.673(10) $\times 10^{-11}$	m <sup>3</sup> kg <sup>-1</sup> s <sup>-2</sup>	energy equivalent in MeV	$m_p c^2$	938.271 998(38)	MeV
Planck constant	$h$	6.626 068 76(52) $\times 10^{-34}$	J s	proton-electron mass ratio	$m_p/m_e$	1 836.152 6675(39)	J T <sup>-1</sup>
in eV s	$h$	4.135 667 27(16) $\times 10^{-15}$	eV s	proton magnetic moment	$\mu_p$	1.410 606 633(58) $\times 10^{-26}$	J T <sup>-1</sup>
in eV s	$h/2\pi$	1.054 571 596(82) $\times 10^{-34}$	J s	to nuclear magneton ratio	$\mu_p/\mu_N$	2.792 847 337(29)	
elementary charge	$e$	1.602 176 462(63) $\times 10^{-19}$	C	proton magnetic shielding correction $1 - \mu_p/\mu_p$	$\sigma_p$	25.687(15) $\times 10^{-6}$	
magnetic flux quantum $h/2e$	$\Phi_0$	2.067 833 636(81) $\times 10^{-15}$	Wb	proton gyromagnetic ratio $2\mu_p/h$	$\gamma_p$	2.675 222 12(11) $\times 10^8$	s <sup>-1</sup> T <sup>-1</sup>
Josephson constant $2e/h$	$K_J$	483 597.898(19) $\times 10^9$	Hz V <sup>-1</sup>	(H <sub>2</sub> O, sphere, 25 °C)	$\gamma_p/2\pi$	42.577 4825(18)	MHz T <sup>-1</sup>
von Klitzing constant $h/e^2 = \mu_0 c/2\alpha$	$R_K$	25 812.807 572(95)	$\Omega$	shielded proton gyromagnetic ratio $2\mu_p^h/h$	$\gamma_p^h$	2.675 153 41(11) $\times 10^8$	s <sup>-1</sup> T <sup>-1</sup>
Bohr magneton $eh/2m_e$	$\mu_B$	927.400 899(37) $\times 10^{-26}$	J T <sup>-1</sup>	neutron mass in u	$m_n$	1.008 664 915 78(55)	u
in eV T <sup>-1</sup>	$\mu_B$	5.788 381 749(43) $\times 10^{-5}$	eV T <sup>-1</sup>	energy equivalent in MeV	$m_n c^2$	939.565 330(38)	MeV
nuclear magneton $eh/2m_p$	$\mu_N$	5.050 783 17(20) $\times 10^{-27}$	J T <sup>-1</sup>	neutron-proton mass ratio	$m_n/m_p$	1.001 378 418 87(58)	J T <sup>-1</sup>
in eV T <sup>-1</sup>	$\mu_N$	3.152 451 238(24) $\times 10^{-8}$	J T <sup>-1</sup>	neutron magnetic moment	$\mu_n$	-0.966 236 40(23) $\times 10^{-26}$	J T <sup>-1</sup>
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	$\alpha$	7.297 352 533(27) $\times 10^{-3}$		to nuclear magneton ratio	$\mu_n/\mu_N$	2.013 553 212 71(35)	
inverse fine-structure constant	$\alpha^{-1}$	137.035 999 76(50)		energy equivalent in MeV	$m_d/m_p$	1.875 612 762(75)	MeV
Rydberg constant $\alpha^2 m_e c/2h$	$R_\infty c$	10 973 731.568 549(83)	m <sup>-1</sup>	deuteron-proton mass ratio	$m_d/m_p$	1.999 007 500 83(44)	MeV
energy equivalent in eV	$R_\infty hc$	3.289 841 960 368(25) $\times 10^{15}$	Hz	deuteron magnetic moment	$\mu_d$	0.433 073 457(18) $\times 10^{-26}$	J T <sup>-1</sup>
Bohr radius $\alpha/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2$	$a_0$	0.529 177 2083(19) $\times 10^{-10}$	m	to nuclear magneton ratio	$\mu_d/\mu_N$	0.857 438 2284(94)	
Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2R_\infty hc = \alpha^2 m_e c^2$	$E_h$	4.359 743 81(34) $\times 10^{-18}$	J	helion ( <sup>3</sup> He nucleus) mass in u	$m_h$	3.014 932 234 69(86)	u
in eV	$E_h$	27.211 3834(11)	eV	energy equivalent in MeV	$m_h c^2$	2 808.391 32(11)	MeV
electron mass	$m_e$	9.109 381 88(72) $\times 10^{-31}$	kg	shielded helion magnetic moment	$\mu_h^h$	-1.074 552 967(45) $\times 10^{-26}$	J T <sup>-1</sup>
in u	$m_e$	5.485 799 110(12) $\times 10^{-4}$	u	(gas, sphere, 25 °C)	$\mu_h^h$		
energy equivalent in MeV	$m_e c^2$	0.510 998 902(21)	MeV	to Bohr magneton ratio	$\mu_h^h/\mu_B$	-1.158 671 474(14) $\times 10^{-3}$	
electron-muon mass ratio	$m_e/m_\mu$	4.836 332 10(15) $\times 10^{-3}$		to nuclear magneton ratio	$\mu_h^h/\mu_N$	-2.127 497 718(25)	
electron-proton mass ratio	$m_e/m_p$	5.446 170 232(12) $\times 10^{-4}$		alpha particle mass in u	$m_\alpha$	4.001 506 1747(10)	u
electron charge to mass quotient	$-e/m_e$	-1.758 820 174(71) $\times 10^{11}$	C kg <sup>-1</sup>	energy equivalent in MeV	$m_\alpha c^2$	3 727.379 04(15)	MeV
Compton wavelength $h/m_e c$	$\lambda_C$	2.426 310 215(18) $\times 10^{-12}$	m	Avogadro constant	$N_A, L$	6.022 141 99(47) $\times 10^{23}$	mol <sup>-1</sup>
$\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\lambda_C$	386.159 2642(28) $\times 10^{-15}$	m	atomic mass constant $\frac{1}{12} m(^{12}\text{C}) = 1$ u	$m_u$	1.660 538 73(13) $\times 10^{-27}$	kg
classical electron radius $\alpha^2 a_0$	$r_e$	2.817 940 285(31) $\times 10^{-15}$	m	energy equivalent in MeV	$m_u c^2$	931.494 013(37)	MeV
Thomson cross section $(8\pi/3)r_e^2$	$\sigma_e$	0.665 245 854(15) $\times 10^{-28}$	m <sup>2</sup>	Faraday constant $N_A e$	$F$	96 485.3415(39)	C mol <sup>-1</sup>
electron magnetic moment	$\mu_e$	-928.476 362(37) $\times 10^{-26}$	J T <sup>-1</sup>	molar gas constant	$R$	8.314 472(15)	J mol <sup>-1</sup> K <sup>-1</sup>
to Bohr magneton ratio	$\mu_e/\mu_B$	-1.001 159 652 1869(41)		Boltzmann constant $R/N_A$	$k$	1.380 6503(24) $\times 10^{-23}$	J K <sup>-1</sup>
to nuclear magneton ratio	$\mu_e/\mu_N$	-1 838.281 9660(39)		in eV K <sup>-1</sup>	$Y_m$	22.413 996(39) $\times 10^{-3}$	eV K <sup>-1</sup>
electron magnetic moment anomaly $ \mu_e/\mu_B - 1$	$a_e$	1.159 652 1869(41) $\times 10^{-3}$		molar volume of ideal gas $RT/p$	$\sigma$	5.670 400(40) $\times 10^{-8}$	W m <sup>-2</sup> K <sup>-4</sup>
electron $g$ -factor $-2(1 + a_e)$	$g_e$	-2.002 319 304 3737(82)		( $T = 273.15$ K, $p = 101.325$ kPa)	$c_1$	3.741 771 07(29) $\times 10^{-16}$	W m <sup>2</sup>
electron-proton magnetic moment ratio	$\mu_e/\mu_p$	-658.210 6875(66)		Stefan-Boltzmann constant $\pi^2 k^4/60\hbar^3 c^2$	$c_2$	1.438 7752(25) $\times 10^{-2}$	W m <sup>2</sup>
muon mass in u	$m_\mu$	0.113 428 9168(34)	u	first radiation constant $2\pi\hbar c^2$	$b$	2.897 7686(51) $\times 10^{-3}$	m K
energy equivalent in MeV	$m_\mu c^2$	105.658 3568(52)	MeV	second radiation constant $hc/k$	$xu(\text{Cu K}\alpha_1)$	1.002 077 03(28) $\times 10^{-13}$	m
muon-electron mass ratio	$m_\mu/m_e$	206.768 2657(63)		Wien displacement law constant	$xu(\text{Mo K}\alpha_1)$	1.002 099 59(53) $\times 10^{-13}$	m
muon magnetic moment	$\mu_\mu$	-4.490 448 13(22) $\times 10^{-26}$	J T <sup>-1</sup>	$b = \lambda_{max} T = c_2/4.965 114 231...$			
to Bohr magneton ratio	$\mu_\mu/\mu_B$	-4.841 970 85(15) $\times 10^{-3}$		Cu x unit: $\lambda(\text{Cu K}\alpha_1)/1.537.400$			
to nuclear magneton ratio	$\mu_\mu/\mu_N$	-8.890 597 70(27)		Mo x unit: $\lambda(\text{Mo K}\alpha_1)/707.831$			
muon magnetic moment anomaly	$a_\mu$	1.165 916 02(64) $\times 10^{-3}$					

### Energy equivalents

(1 J)	= 6.241 509 74(24) $\times 10^{18}$ eV	(1 eV)/c <sup>2</sup>	= 1.073 544 206(43) $\times 10^{-9}$ u
(1 eV)	= 1.602 176 462(63) $\times 10^{-19}$ J	(1 kg)	= 6.022 141 99(47) $\times 10^{26}$ u
(1 eV)/ $hc$	= 8.065 544 77(32) $\times 10^5$ m <sup>-1</sup>	(1 u)	= 1.660 538 73(13) $\times 10^{-27}$ kg
(1 eV)/ $h$	= 2.417 989 491(95) $\times 10^{14}$ Hz	(1 u)c/ $h$	= 7.513 006 658(57) $\times 10^{14}$ m <sup>-1</sup>
(1 eV)/ $k$	= 1.160 4506(20) $\times 10^4$ K	(1 u)c <sup>2</sup>	= 931.494 013(37) $\times 10^6$ eV



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# 1998 CODATA RECOMMENDED VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS

NIST SP 961A (Jan/2001) Values from: P. J. Mohr and B. N. Taylor, J. Phys.

A more extensive listing of constants is available in the above references and The number in parenthesis is the one-standard-deviation

Quantity	Symbol	Numerical value	Unit
speed of light in vacuum	$c, c_0$	299 792 458 (exact)	$\text{m s}^{-1}$
magnetic constant	$\mu_0$	$4\pi \times 10^{-7}$ (exact) $= 12.566 370 614 \dots \times 10^{-7}$	$\text{N A}^{-2}$ $\text{N A}^{-2}$
electric constant $1/\mu_0 c^2$	$\epsilon_0$	$8.854 187 817 \dots \times 10^{-12}$	$\text{F m}^{-1}$
Newtonian constant of gravitation	$G$	$6.673(10) \times 10^{-11}$	$\text{m}^3 \text{kg}^{-1} \text{s}^{-2}$
Planck constant	$h$	$6.626 068 76(52) \times 10^{-34}$ $4.135 667 27(16) \times 10^{-15}$	$\text{J s}$ $\text{eV s}$
in eV s	$\hbar$	$1.054 571 596(82) \times 10^{-34}$ $6.582 118 89(26) \times 10^{-16}$	$\text{J s}$ $\text{eV s}$
$h/2\pi$	$\hbar$	$1.054 571 596(82) \times 10^{-34}$ $6.582 118 89(26) \times 10^{-16}$	$\text{J s}$ $\text{eV s}$
elementary charge	$e$	$1.602 176 462(63) \times 10^{-19}$	$\text{C}$
magnetic flux quantum $h/2e$	$\Phi_0$	$2.067 833 636(81) \times 10^{-15}$	$\text{Wb}$
Josephson constant $2e/h$	$K_J$	$483 597.898(19) \times 10^9$	$\text{Hz V}^{-1}$
von Klitzing constant $h/e^2 = \mu_0 c/2\alpha$	$R_K$	$25 812.807 572(95)$	$\Omega$
Bohr magneton $e\hbar/2m_e$	$\mu_B$	$927.400 899(37) \times 10^{-26}$ $5.788 381 749(43) \times 10^{-5}$	$\text{J T}^{-1}$ $\text{eV T}^{-1}$
in eV $\text{T}^{-1}$	$\mu_B$	$927.400 899(37) \times 10^{-26}$ $5.788 381 749(43) \times 10^{-5}$	$\text{J T}^{-1}$ $\text{eV T}^{-1}$
nuclear magneton $e\hbar/2m_p$	$\mu_N$	$5.050 783 17(20) \times 10^{-27}$ $3.152 451 238(24) \times 10^{-8}$	$\text{J T}^{-1}$ $\text{eV T}^{-1}$
in eV $\text{T}^{-1}$	$\mu_N$	$5.050 783 17(20) \times 10^{-27}$ $3.152 451 238(24) \times 10^{-8}$	$\text{J T}^{-1}$ $\text{eV T}^{-1}$
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	$\alpha$	$7.297 352 533(27) \times 10^{-3}$ $137.035 999 76(50)$	
inverse fine-structure constant	$\alpha^{-1}$	$137.035 999 76(50)$	
Rydberg constant $\alpha^2 m_e c/2h$	$R_\infty$	$10 973 731.568 549(83)$	$\text{m}^{-1}$
energy equivalent in eV	$R_\infty hc$	$13.605 691 72(53)$	$\text{eV}$
Bohr radius $\alpha/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2$	$a_0$	$0.529 177 2083(19) \times 10^{-10}$	$\text{m}$
Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2R_\infty hc = \alpha^2 m_e c^2$	$E_h$	$4.359 743 81(34) \times 10^{-18}$ $27 211 3834(11)$	$\text{J}$ $\text{eV}$



# 1998 CODATA RECOMMENDED VALUES OF THE FUNDAMENTAL CONSTANTS OF PHYSICS AND CHEMISTRY

NIST SP 961A(Jan/2001) Values from: P. J. Mohr and B. N. Taylor, J. Phys. Chem. Ref. Data **28**, 1713 (1999) and Rev. Mod. Phys. **72**, 351 (2000).

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

Quantity	Symbol	Numerical value	Unit	Quantity	Symbol	Numerical value	Unit
speed of light in vacuum	$c, c_0$	299 792 458 (exact)	$\text{m s}^{-1}$	muon $g$ -factor $-2(1 + a_\mu)$	$g_\mu$	$-2.002\,331\,8320(13)$	
magnetic constant	$\mu_0$	$4\pi \times 10^{-7}$ (exact)	$\text{N A}^{-2}$	muon-proton magnetic moment ratio	$\mu_\mu/\mu_p$	$-3.183\,345\,39(10)$	
		$= 12.566\,370\,614\dots \times 10^{-7}$	$\text{N A}^{-2}$	proton mass	$m_p$	$1.672\,621\,58(13) \times 10^{-27}$	kg
electric constant $1/\mu_0 c^2$	$\epsilon_0$	$8.854\,187\,817\dots \times 10^{-12}$	$\text{F m}^{-1}$	in u		$1.007\,276\,466\,88(13)$	u
Newtonian constant of gravitation	$G$	$6.673(10) \times 10^{-11}$	$\text{m}^3 \text{kg}^{-1} \text{s}^{-2}$	energy equivalent in MeV	$m_p c^2$	$938.271\,998(38)$	MeV
Planck constant	$h$	$6.626\,068\,76(52) \times 10^{-34}$	J s	proton-electron mass ratio	$m_p/m_e$	$1\,836.152\,6675(39)$	
in eV s		$4.135\,667\,27(16) \times 10^{-15}$	eV s	proton magnetic moment	$\mu_p$	$1.410\,606\,633(58) \times 10^{-26}$	$\text{J T}^{-1}$
$h/2\pi$	$\hbar$	$1.054\,571\,596(82) \times 10^{-34}$	J s	to nuclear magneton ratio	$\mu_p/\mu_N$	$2.792\,847\,337(29)$	
in eV s		$6.582\,118\,89(26) \times 10^{-16}$	eV s	proton magnetic shielding correction $1 - \mu'_p/\mu_p \sigma'_p$		$25.687(15) \times 10^{-6}$	
elementary charge	$e$	$1.602\,176\,462(63) \times 10^{-19}$	C	( $\text{H}_2\text{O}$ , sphere, $25^\circ\text{C}$ )			
magnetic flux quantum $h/2e$	$\Phi_0$	$2.067\,833\,636(81) \times 10^{-15}$	Wb	proton gyromagnetic ratio $2\mu_p/\hbar$	$\gamma_p$	$2.675\,222\,12(11) \times 10^8$	$\text{s}^{-1} \text{T}^{-1}$
Josephson constant $2e/h$	$K_J$	$483\,597.898(19) \times 10^9$	$\text{Hz V}^{-1}$		$\gamma_p/2\pi$	$42.577\,4825(18)$	$\text{MHz T}^{-1}$
von Klitzing constant $h/e^2 = \mu_0 c/2\alpha$	$R_K$	$25\,812.807\,572(95)$	$\Omega$	shielded proton gyromagnetic ratio $2\mu'_p/\hbar$	$\gamma'_p$	$2.675\,153\,41(11) \times 10^8$	$\text{s}^{-1} \text{T}^{-1}$
Bohr magneton $eh/2m_e$	$\mu_B$	$927.400\,899(37) \times 10^{-26}$	$\text{J T}^{-1}$	( $\text{H}_2\text{O}$ , sphere, $25^\circ\text{C}$ )			
in eV $\text{T}^{-1}$		$5.788\,381\,749(43) \times 10^{-5}$	eV $\text{T}^{-1}$		$\gamma'_p/2\pi$	$42.576\,3888(18)$	$\text{MHz T}^{-1}$
nuclear magneton $eh/2m_p$	$\mu_N$	$5.050\,783\,17(20) \times 10^{-27}$	$\text{J T}^{-1}$	neutron mass in u	$m_n$	$1.008\,664\,915\,78(55)$	u
in eV $\text{T}^{-1}$		$3.152\,451\,238(24) \times 10^{-8}$	eV $\text{T}^{-1}$	energy equivalent in MeV	$m_n c^2$	$939.565\,330(38)$	MeV
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	$\alpha$	$7.297\,352\,533(27) \times 10^{-3}$		neutron-proton mass ratio	$m_n/m_p$	$1.001\,378\,418\,87(58)$	
inverse fine-structure constant	$\alpha^{-1}$	$137.035\,999\,76(50)$		neutron magnetic moment	$\mu_n$	$-0.966\,236\,40(23) \times 10^{-26}$	$\text{J T}^{-1}$
Rydberg constant $\alpha^2 m_e c/2h$	$R_\infty$	$10\,973\,731.568\,549(83)$	$\text{m}^{-1}$	to nuclear magneton ratio	$\mu_n/\mu_N$	$-1.913\,042\,72(45)$	
energy equivalent in eV	$R_\infty c$	$3.289\,841\,960\,368(25) \times 10^{15}$	Hz	deuteron mass in u	$m_d$	$2.013\,553\,212\,71(35)$	u
Bohr radius $a_0/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_e e^2$	$R_\infty \hbar c$	$13.605\,691\,72(53)$	eV	energy equivalent in MeV	$m_d c^2$	$1\,875.612\,762(75)$	MeV
Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2R_\infty \hbar c = \alpha^2 m_e c^2$	$a_0$	$0.529\,177\,2083(19) \times 10^{-10}$	m	deuteron-proton mass ratio	$m_d/m_p$	$1.999\,007\,500\,83(41)$	
in eV	$E_h$	$4.359\,743\,81(34) \times 10^{-18}$	J	deuteron magnetic moment	$\mu_d$	$0.433\,073\,457(18) \times 10^{-26}$	$\text{J T}^{-1}$
electron mass	$m_e$	$9.109\,381\,88(72) \times 10^{-31}$	kg	to nuclear magneton ratio	$\mu_d/\mu_N$	$0.857\,438\,2284(94)$	
in u		$5.485\,799\,110(12) \times 10^{-4}$	u	helion ( $^3\text{He}$ nucleus) mass in u	$m_h$	$3.014\,932\,234\,69(86)$	u
energy equivalent in MeV	$m_e c^2$	$0.510\,998\,902(21)$	MeV	energy equivalent in MeV	$m_h c^2$	$2\,808.391\,32(11)$	MeV
electron-muon mass ratio	$m_e/m_\mu$	$4.836\,332\,10(15) \times 10^{-3}$		shielded helion magnetic moment	$\mu'_h$	$-1.074\,552\,967(45) \times 10^{-26}$	$\text{J T}^{-1}$
electron-proton mass ratio	$m_e/m_p$	$5.446\,170\,232(12) \times 10^{-4}$		(gas, sphere, $25^\circ\text{C}$ )			
electron charge to mass quotient	$-e/m_e$	$-1.758\,820\,174(71) \times 10^{11}$	$\text{C kg}^{-1}$	to Bohr magneton ratio	$\mu'_h/\mu_B$	$-1.158\,671\,474(14) \times 10^{-3}$	
Compton wavelength $h/m_e c$	$\lambda_C$	$2.426\,310\,215(18) \times 10^{-12}$	m	to nuclear magneton ratio	$\mu'_h/\mu_N$	$-2.127\,497\,718(25)$	
$\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\lambda_C$	$386.159\,2642(28) \times 10^{-15}$	m	alpha particle mass in u	$m_\alpha$	$4.001\,506\,1747(10)$	u
classical electron radius $\alpha^2 a_0$	$r_e$	$2.817\,940\,285(31) \times 10^{-15}$	m	energy equivalent in MeV	$m_\alpha c^2$	$3\,727.379\,04(15)$	MeV
Thomson cross section $(8\pi/3)r_e^2$	$\sigma_e$	$0.665\,245\,854(15) \times 10^{-28}$	$\text{m}^2$	Avogadro constant	$N_A, L$	$6.022\,141\,99(47) \times 10^{23}$	$\text{mol}^{-1}$
electron magnetic moment	$\mu_e$	$-928.476\,362(37) \times 10^{-26}$	$\text{J T}^{-1}$	atomic mass constant $\frac{1}{12}m(^{12}\text{C}) = 1 \text{ u}$	$m_u$	$1.660\,538\,73(13) \times 10^{-27}$	kg
to Bohr magneton ratio	$\mu_e/\mu_B$	$-1.001\,159\,652\,1869(41)$		energy equivalent in MeV	$m_u c^2$	$931.494\,013(37)$	MeV
to nuclear magneton ratio	$\mu_e/\mu_N$	$-1.838\,281\,9660(39)$		Faraday constant $N_A e$	$F$	$96\,485.3415(39)$	$\text{C mol}^{-1}$
electron magnetic moment anomaly $ \mu_e /\mu_B - 1$	$a_e$	$1.159\,652\,1869(41) \times 10^{-3}$		molar gas constant	$R$	$8.314\,472(15)$	$\text{J mol}^{-1} \text{K}^{-1}$
electron $g$ -factor $-2(1 + a_e)$	$g_e$	$-2.002\,319\,304\,3737(82)$		Boltzmann constant $R/N_A$	$k$	$1.380\,6503(24) \times 10^{-23}$	$\text{J K}^{-1}$
electron-proton magnetic moment ratio	$\mu_e/\mu_p$	$-658.210\,6875(66)$		in eV $\text{K}^{-1}$		$8.617\,342(15) \times 10^{-5}$	eV $\text{K}^{-1}$
muon mass in u	$m_\mu$	$0.113\,428\,9168(34)$	u	molar volume of ideal gas $RT/p$	$V_m$	$22.413\,996(39) \times 10^{-3}$	$\text{m}^3 \text{mol}^{-1}$
energy equivalent in MeV	$m_\mu c^2$	$105.658\,3568(52)$	MeV	( $T = 273.15 \text{ K}$ , $p = 101.325 \text{ kPa}$ )			
muon-electron mass ratio	$m_\mu/m_e$	$206.768\,2657(63)$		Stefan-Boltzmann constant $\pi^2 k^4/60\hbar^3 c^2$	$\sigma$	$5.670\,400(40) \times 10^{-8}$	$\text{W m}^{-2} \text{K}^{-4}$
muon magnetic moment	$\mu_\mu$	$-4.490\,448\,13(22) \times 10^{-26}$	$\text{J T}^{-1}$	first radiation constant $2\pi\hbar c^2$	$c_1$	$3.741\,771\,07(29) \times 10^{-16}$	$\text{W m}^2$
to Bohr magneton ratio	$\mu_\mu/\mu_B$	$-4.841\,970\,85(15) \times 10^{-3}$		second radiation constant $\hbar c/k$	$c_2$	$1.438\,7752(25) \times 10^{-2}$	m K
to nuclear magneton ratio	$\mu_\mu/\mu_N$	$-8.890\,597\,70(27)$		Wien displacement law constant			
muon magnetic moment anomaly				$b = \lambda_{\text{max}} T = c_2/4.965\,114\,231\dots$	$b$	$2.897\,7686(51) \times 10^{-3}$	m K
$ \mu_\mu /(e\hbar/2m_\mu) - 1$	$a_\mu$	$1.165\,916\,02(64) \times 10^{-3}$		Cu x unit: $\lambda(\text{Cu K}\alpha_1)/1\,537.400$	$xu(\text{Cu K}\alpha_1)$	$1.002\,077\,03(28) \times 10^{-13}$	m
				Mo x unit: $\lambda(\text{Mo K}\alpha_1)/707.831$	$xu(\text{Mo K}\alpha_1)$	$1.002\,099\,59(53) \times 10^{-13}$	m

### Energy equivalents

$(1 \text{ m}^{-1})c = 299\,792\,458 \text{ Hz}$	$(1 \text{ Hz})\hbar/k = 4.799\,2374(84) \times 10^{-11} \text{ K}$	$(1 \text{ J}) = 6.241\,509\,74(24) \times 10^{18} \text{ eV}$	$(1 \text{ eV})/c^2 = 1.073\,544\,206(43) \times 10^{-9} \text{ u}$
$(1 \text{ m}^{-1})\hbar c/k = 1.438\,7752(25) \times 10^{-2} \text{ K}$	$(1 \text{ Hz})\hbar = 4.135\,667\,27(16) \times 10^{-15} \text{ eV}$	$(1 \text{ eV}) = 1.602\,176\,462(63) \times 10^{-19} \text{ J}$	$(1 \text{ kg}) = 6.022\,141\,99(47) \times 10^{26} \text{ u}$
$(1 \text{ m}^{-1})\hbar c = 1.239\,841\,857(49) \times 10^{-6} \text{ eV}$	$(1 \text{ K})k/\hbar c = 69.503\,56(12) \text{ m}^{-1}$	$(1 \text{ eV})/\hbar c = 8.065\,544\,77(32) \times 10^5 \text{ m}^{-1}$	$(1 \text{ u}) = 1.660\,538\,73(13) \times 10^{-27} \text{ kg}$
$(1 \text{ m}^{-1})\hbar/c = 1.331\,025\,042(10) \times 10^{-15} \text{ u}$	$(1 \text{ K})k/\hbar = 2.083\,6644(36) \times 10^{10} \text{ Hz}$	$(1 \text{ eV})/\hbar = 2.417\,989\,491(95) \times 10^{14} \text{ Hz}$	$(1 \text{ u})c/\hbar = 7.513\,006\,658(57) \times 10^{14} \text{ m}^{-1}$
$(1 \text{ Hz})/c = 3.335\,640\,952 \times 10^{-9} \text{ m}^{-1}$	$(1 \text{ K})k = 8.617\,342(15) \times 10^{-5} \text{ eV}$	$(1 \text{ eV})/k = 1.160\,4506(20) \times 10^4 \text{ K}$	$(1 \text{ u})c^2 = 931.494\,013(37) \times 10^6 \text{ eV}$





energy equivalent in MeV	in u			
electron-muon mass ratio	$m_e c^2$	5.485 799 110(12) $\times 10^{-4}$	u	
electron-proton mass ratio	$m_e/m_\mu$	0.510 998 902(21)	MeV	
electron charge to mass quotient	$m_e/m_p$	4.836 332 10(15) $\times 10^{-3}$		
Compton wavelength $h/m_e c$	$-e/m_e$	5.446 170 232(12) $\times 10^{-4}$		
$\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\lambda_C$	$-1.758 820 174(71) \times 10^{11}$	C kg <sup>-1</sup>	
classical electron radius $\alpha^2 a_0$	$\lambda_C$	2.426 310 215(18) $\times 10^{-12}$	m	
Thomson cross section $(8\pi/3)r_e^2$	$r_e$	386.159 2642(28) $\times 10^{-15}$	m	
electron magnetic moment	$\sigma_e$	2.817 940 285(31) $\times 10^{-15}$	m	
to Bohr magneton ratio	$\mu_e$	0.665 245 854(15) $\times 10^{-28}$	m <sup>2</sup>	
to nuclear magneton ratio	$\mu_e/\mu_B$	$-928.476 362(37) \times 10^{-26}$	J T <sup>-1</sup>	
electron magnetic moment anomaly $ \mu_e /\mu_B - 1$	$\mu_e/\mu_N$	$-1.001 159 652 1869(41)$		
electron $g$ -factor $-2(1 + a_e)$	$a_e$	$-1 838.281 9660(39)$		
electron-proton magnetic moment ratio	$g_e$	1.159 652 1869(41) $\times 10^{-3}$		
muon mass in u	$\mu_e/\mu_p$	$-2.002 319 304 3737(82)$		
energy equivalent in MeV	$m_\mu$	$-658.210 6875(66)$	u	
muon-electron mass ratio	$m_\mu c^2$	0.113 428 9168(34)	MeV	
muon magnetic moment	$m_\mu/m_e$	105.658 3568(52)		
to Bohr magneton ratio	$\mu_\mu$	206.768 2657(63)		
to nuclear magneton ratio	$\mu_\mu/\mu_B$	$-4.490 448 13(22) \times 10^{-26}$	J T <sup>-1</sup>	
muon magnetic moment anomaly	$\mu_\mu/\mu_N$	$-4.841 970 85(15) \times 10^{-3}$		
	$a_\mu$	$-8.890 597 70(27)$		
		1.165 916 02(64) $\times 10^{-3}$		

Energy eq

$(1 \text{ m}^{-1})c$	$= 299 792 458 \text{ Hz}$	$(1 \text{ Hz})h/k = 4.799 2374(84) \times 10^{-11} \text{ K}$
$(1 \text{ m}^{-1})hc/k$	$= 1.438 7752(25) \times 10^{-2} \text{ K}$	$(1 \text{ Hz})h = 4.135 667 27(16) \times 10^{-15} \text{ eV}$
$(1 \text{ m}^{-1})hc$	$= 1.239 841 857(49) \times 10^{-6} \text{ eV}$	$(1 \text{ K})k/hc = 69.503 56(12) \text{ m}^{-1}$
$(1 \text{ m}^{-1})h/c$	$= 1.331 025 042(10) \times 10^{-15} \text{ u}$	$(1 \text{ K})k/h = 2.083 6644(36) \times 10^{10} \text{ Hz}$
$(1 \text{ Hz})/c$	$= 3.335 640 952 \times 10^{-9} \text{ m}^{-1}$	$(1 \text{ K})k = 8.617 342(15) \times 10^{-5} \text{ eV}$

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