FUNDAMENTAL PHYSICAL CONSTANTS

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These tables give the 2002 self-consistent set of values of the basic constants and conversion factors of physics and chemistry recommended by the Committee on Data for Science and Technology (CODATA) for international use. The 2002 set replaces the previously recommended 1998 CODATA set. The 2002 adjustment takes into account the data considered in the 1998 adjustment as well as the data that became available between 31 December 1998, the closing date of that adjustment, and 31 December 2002, the closing date of the new adjustment.

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Reference

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TABLE I. An Abbreviated List of the CODATA Recommended Values of the Fundamental Constants of Physics and Chemistry Based on the 2002 Adjustment

Quanity	Symbol	Numerical value	Unit	Relative std. uncert. u_r
speed of light in vacuum	c, c_0	299 792 458	m s^{-1}	(exact)
magnetic constant	μ_0	$4\pi \times 10^{-7}$	N A^{-2}	
		$= 12.566\,370\,614... \times 10^{-7}$	N A^{-2}	(exact)
electric constant $1/\mu_0 c^2$	ε_0	$8.854\,187\,817... \times 10^{-12}$	F m^{-1}	(exact)
Newtonian constant of gravitation	G	$6.6742(10) \times 10^{-11}$	m^3 kg^{-1} s^{-2}	1.5×10^{-4}
Planck constant	h	$6.626\,0693(11) \times 10^{-34}$	J s	1.7×10^{-7}
$h/2\pi$	$\hbar$	$1.054\,571\,68(18) \times 10^{-34}$	J s	1.7×10^{-7}
elementary charge	e	$1.602\,176\,53(14) \times 10^{-19}$	C	8.5×10^{-8}
magnetic flux quantum $h/2e$	Φ_0	$2.067\,833\,72(18) \times 10^{-15}$	Wb	8.5×10^{-8}
conductance quantum $2e^2/h$	G_0	$7.748\,091\,733(26) \times 10^{-5}$	S	3.3×10^{-9}
electron mass	m_e	$9.109\,3826(16) \times 10^{-31}$	kg	1.7×10^{-7}
proton mass	m_p	$1.672\,621\,71(29) \times 10^{-27}$	kg	1.7×10^{-7}
proton-electron mass ratio	m_p/m_e	1836.152 672 61(85)		4.6×10^{-10}
fine-structure constant $e^2/4\pi\varepsilon_0\hbar c$	α	$7.297\,352\,568(24) \times 10^{-3}$		3.3×10^{-9}
inverse fine-structure constant	α^{-1}	137.035 999 11(46)		3.3×10^{-9}
Rydberg constant $\alpha^2 m_e c/2h$	R_∞	10 973 731.568 525(73)	m^{-1}	6.6×10^{-12}
Avogadro constant	N_A, L	$6.022\,1415(10) \times 10^{23}$	mol^{-1}	1.7×10^{-7}
Faraday constant $N_A e$	F	96 485.3383(83)	C mol^{-1}	8.6×10^{-8}
molar gas constant	R	8.314 472(15)	J mol^{-1} K^{-1}	1.7×10^{-6}
Boltzmann constant R/N_A	k	$1.380\,6505(24) \times 10^{-23}$	J K^{-1}	1.8×10^{-6}
Stefan-Boltzmann constant $(\pi^2/60)k^4/\hbar^3c^2$	σ	$5.670\,400(40) \times 10^{-8}$	W m^{-2} K^{-4}	7.0×10^{-6}
Non-SI units accepted for use with the SI				
electron volt: (e/C) J	eV	$1.602\,176\,53(14) \times 10^{-19}$	J	8.5×10^{-8}
(unified) atomic mass unit	u	$1.660\,538\,86(28) \times 10^{-27}$	kg	1.7×10^{-7}
1 u = $m_u = (1/12)m(^{12}C) = 10^{-3}$ kg mol$^{-1}/N_A$				

TABLE II. The CODATA Recommended Values of the Fundamental Constants of Physics and Chemistry Based on the 2002 Adjustment

Quantity	Symbol	Numerical value	Unit	Relative std. uncert. u_r
Universal				
speed of light in vacuum	c, c_0	299 792 458	m s^{-1}	(exact)
magnetic constant	μ_0	$4\pi \times 10^{-7}$	N A^{-2}	
		$= 12.566\,370\,614... \times 10^{-7}$	N A^{-2}	(exact)
electric constant $1/\mu_0 c^2$	ε_0	$8.854\,187\,817... \times 10^{-12}$	F m^{-1}	(exact)
characteristic impedance of vacuum $\sqrt{\mu_0/\varepsilon_0} = \mu_0 c$	Z_0	376.730 313 461...	Ω	(exact)
Newtonian constant of gravitation	G	$6.6742(10) \times 10^{-11}$	m^3 kg^{-1} s^{-2}	1.5×10^{-4}
	$G/\hbar c$	$6.7087(10) \times 10^{-39}$	(GeV/c^2)$^{-2}$	1.5×10^{-4}
Planck constant	h	$6.626\,0693(11) \times 10^{-34}$	J s	1.7×10^{-7}
in eV s		$4.135\,667\,43(35) \times 10^{-15}$	eV s	8.5×10^{-8}
$h/2\pi$	$\hbar$	$1.054\,571\,68(18) \times 10^{-34}$	J s	1.7×10^{-7}
in eV s		$6.582\,119\,15(56) \times 10^{-16}$	eV s	8.5×10^{-8}
$\hbar c$ in MeV fm		197.326 968(17)	MeV fm	8.5×10^{-8}
Planck mass $(\hbar c/G)^{1/2}$	m_P	$2.176\,45(16) \times 10^{-8}$	kg	7.5×10^{-5}
Planck temperature $(\hbar c^5/G)^{1/2}/k$	T_P	$1.416\,79(11) \times 10^{32}$	K	7.5×10^{-5}
Planck length $\hbar/m_P c = (\hbar G/c^3)^{1/2}$	l_P	$1.616\,24(12) \times 10^{-35}$	m	7.5×10^{-5}
Planck time $l_P/c = (\hbar G/c^5)^{1/2}$	t_P	$5.391\,21(40) \times 10^{-44}$	s	7.5×10^{-5}
Electromagnetic				
elementary charge	e	$1.602\,176\,53(14) \times 10^{-19}$	C	8.5×10^{-8}
	e/h	$2.417\,989\,40(21) \times 10^{14}$	A J^{-1}	8.5×10^{-8}
magnetic flux quantum $h/2e$	Φ_0	$2.067\,833\,72(18) \times 10^{-15}$	Wb	8.5×10^{-8}
conductance quantum $2e^2/h$	G_0	$7.748\,091\,733(26)\times10^{-5}$	S	3.3×10^{-9}
inverse of conductance quantum	G_0^{-1}	12 906.403 725(43)	Ω	3.3×10^{-9}
Josephson constant[1] $2e/h$	K_J	$483\,597.879(41)\times10^{9}$	Hz V^{-1}	8.5×10^{-8}
von Klitzing constant[2] $h/e^2 = \mu_0 c/2\alpha$	R_K	25 812.807 449(86)	Ω	3.3×10^{-9}
Bohr magneton $e\hbar/2m_e$	μ_B	$927.400\,949(80)\times10^{-26}$	J T^{-1}	8.6×10^{-8}
in eV T^{-1}		$5.788\,381\,804(39)\times10^{-5}$	eV T^{-1}	6.7×10^{-9}
	μ_B/h	$13.996\,2458(12)\times10^{9}$	Hz T^{-1}	8.6×10^{-8}
	μ_B/hc	46.686 4507(40)	m^{-1} T^{-1}	8.6×10^{-8}
	μ_B/k	0.671 7131(12)	K T^{-1}	1.8×10^{-6}
nuclear magneton $e\hbar/2m_p$	μ_N	$5.050\,783\,43(43)\times10^{-27}$	J T^{-1}	8.6×10^{-8}
in eV T^{-1}		$3.152\,451\,259(21)\times10^{-8}$	eV T^{-1}	6.7×10^{-9}
	μ_N/h	7.622 593 71(65)	MHz T^{-1}	8.6×10^{-8}
	μ_N/hc	$2.542\,623\,58(22)\times10^{-2}$	m^{-1} T^{-1}	8.6×10^{-8}
	μ_N/k	$3.658\,2637(64)\times10^{-4}$	K T^{-1}	1.8×10^{-6}
Atomic and Nuclear				
General				
Fine-structure constant $e^2/4\pi\varepsilon_0\hbar c$	α	$7.297\,352\,568(24)\times10^{-3}$		3.3×10^{-9}
inverse fine-structure constant	α^{-1}	137.035 999 11(46)		3.3×10^{-9}
Rydberg constant $\alpha^2 m_e c/2h$	R_∞	10 973 731.568 525(73)	m^{-1}	6.6×10^{-12}
	$R_\infty c$	$3.289\,841\,960\,360(22)\times10^{15}$	Hz	6.6×10^{-12}
	$R_\infty hc$	$2.179\,872\,09(37)\times10^{-18}$	J	1.7×10^{-7}
$R_\infty hc$ in eV		13.605 6923(12)	eV	8.5×10^{-8}
Bohr radius $\alpha/4\pi R_\infty = 4\pi\varepsilon_0\hbar^2/m_e e^2$	a_0	$0.529\,177\,2108(18)\times10^{-10}$	m	3.3×10^{-9}
Hartree energy $e^2/4\pi\varepsilon_0 a_0 = 2R_\infty hc = \alpha^2 m_e c^2$	E_h	$4.359\,744\,17(75)\times10^{-18}$	J	1.7×10^{-7}
in eV		27.211 3845(23)	eV	8.5×10^{-8}
quantum of circulation	$h/2m_e$	$3.636\,947\,550(24)\times10^{-4}$	m^{2}s^{-1}	6.7×10^{-9}
	h/m_e	$7.273\,895\,101(48)\times10^{-4}$	m^{2}s^{-1}	6.7×10^{-9}
Electroweak				
Fermi coupling constant[3]	$G_F/(\hbar c)^3$	$1.166\,39(1)\times10^{-5}$	GeV^{-2}	8.6×10^{-6}
weak mixing angle[4] θ_W (on-shell scheme) $\sin^2\theta_W = s_W^2 \equiv 1-(m_W/m_Z)^2$	$\sin^2\theta_W$	0.222 15(76)		3.4×10^{-3}
Electron, e^-				
electron mass	m_e	$9.109\,3826(16)\times10^{-31}$	kg	1.7×10^{-7}
in u, $m_e = A_r(e)$ u (electron relative atomic mass times u)		$5.485\,799\,0945(24)\times10^{-4}$	u	4.4×10^{-10}

Quantity	Symbol	Numerical value	Unit	Relative std. uncert. u_r
energy equivalent	$m_e c^2$	$8.187\,1047(14)\times10^{-14}$	J	1.7×10^{-7}
in MeV		$0.510\,998\,918(44)$	MeV	8.6×10^{-8}
electron-muon mass ratio	m_e/m_μ	$4.836\,331\,67(13)\times10^{-3}$		2.6×10^{-8}
electron-tau mass ratio	m_e/m_τ	$2.875\,64(47)\times10^{-4}$		1.6×10^{-4}
electron-proton mass ratio	m_e/m_p	$5.446\,170\,2173(25)\times10^{-4}$		4.6×10^{-10}
electron-neutron mass ratio	m_e/m_n	$5.438\,673\,4481(38)\times10^{-4}$		7.0×10^{-10}
electron-deuteron mass ratio	m_e/m_d	$2.724\,437\,1095(13)\times10^{-4}$		4.8×10^{-10}
electron to alpha particle mass ratio	m_e/m_α	$1.370\,933\,555\,75(61)\times10^{-4}$		4.4×10^{-10}
electron charge to mass quotient	$-e/m_e$	$-1.758\,820\,12(15)\times10^{11}$	C kg^{-1}	8.6×10^{-8}
electron molar mass $N_A m_e$	$M(e)$, M_e	$5.485\,799\,0945(24)\times10^{-7}$	kg mol^{-1}	4.4×10^{-10}
Compton wavelength $h/m_e c$	λ_C	$2.426\,310\,238(16)\times10^{-12}$	m	6.7×10^{-9}
$\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\bar{\lambda}_C$	$386.159\,2678(26)\times10^{-15}$	m	6.7×10^{-9}
classical electron radius $\alpha^2 a_0$	r_e	$2.817\,940\,325(28)\times10^{-15}$	m	1.0×10^{-8}
Thomson cross section $(8\pi/3)r_e^2$	σ_e	$0.665\,245\,873(13)\times10^{-28}$	m^2	2.0×10^{-8}
electron magnetic moment	μ_e	$-928.476\,412(80)\times10^{-26}$	J T^{-1}	8.6×10^{-8}
to Bohr magneton ratio	μ_e/μ_B	$-1.001\,159\,652\,1859(38)$		3.8×10^{-12}
to nuclear magneton ratio	μ_e/μ_N	$-1838.281\,971\,07(85)$		4.6×10^{-10}
electron magnetic moment anomaly $\lvert\mu_e\rvert/\mu_B - 1$	a_e	$1.159\,652\,1859(38)\times10^{-3}$		3.2×10^{-9}
electron g-factor $-2(1 + a_e)$	g_e	$-2.002\,319\,304\,3718(75)$		3.8×10^{-12}
electron-muon magnetic moment ratio	μ_e/μ_μ	$206.766\,9894(54)$		2.6×10^{-8}
electron-proton magnetic moment ratio	$\mu_e \mu_p$	$-658.210\,6862(66)$		1.0×10^{-8}
electron to shielded proton magnetic moment ratio (H_2O, sphere, 25°C)	μ_e/μ'_p	$-658.227\,5956(71)$		1.1×10^{-8}
electron-neutron magnetic moment ratio	μ_e/μ_n	$960.920\,50(23)$		2.4×10^{-7}
electron-deuteron magnetic moment ratio	μ_e/μ_d	$-2\,143.923\,493(23)$		1.1×10^{-8}
electron to shielded helion[5] magnetic moment ratio (gas, sphere, 25°C)	μ_e/μ'_h	$864.058\,255(10)$		1.2×10^{-8}
electron gyromagnetic ratio $2\lvert\mu_e\rvert/\hbar$	γ_e	$1.760\,859\,74(15)\times10^{11}$	s^{-1} T^{-1}	8.6×10^{-8}
	$\gamma_e/2\pi$	$28\,024.9532(24)$	MHz T^{-1}	8.6×10^{-8}
Muon, μ^-				
muon mass	m_μ	$1.883\,531\,40(33)\times10^{-28}$	kg	1.7×10^{-7}
in u, $m_\mu = A_r(\mu)$ u (muon relative atomic mass times u)		$0.113\,428\,9264(30)$	u	2.6×10^{-8}
energy equivalent	$m_\mu c^2$	$1.692\,833\,60(29)\times10^{-11}$	J	1.7×10^{-7}
in MeV		$105.658\,3692(94)$	MeV	8.9×10^{-8}
muon-electron mass ratio	m_μ/m_e	$206.768\,2838(54)$		2.6×10^{-8}
muon-tau mass ratio	m_μ/m_τ	$5.945\,92(97)\times10^{-2}$		1.6×10^{-4}
muon-proton mass ratio	m_μ/m_p	$0.112\,609\,5269(29)$		2.6×10^{-8}
muon-neutron mass ratio	m_μ/m_n	$0.112\,454\,5175(29)$		2.6×10^{-8}
muon molar mass $N_A m_\mu$	$M(\mu)$, M_μ	$0.113\,428\,9264(30)\times10^{-3}$	kg mol^{-1}	2.6×10^{-8}
muon Compton wavelength $h/m_\mu c$	$\lambda_{C,\mu}$	$11.734\,441\,05(30)\times10^{-15}$	m	2.5×10^{-8}
$\lambda_{C,\mu}/2\pi$	$\bar{\lambda}_{C,\mu}$	$1.867\,594\,298(47)\times10^{-15}$	m	2.5×10^{-8}
muon magnetic moment	μ_μ	$-4.490\,447\,99(40)\times10^{-26}$	J T^{-1}	8.9×10^{-8}
to Bohr magneton ratio	μ_μ/μ_B	$-4.841\,970\,45(13)\times10^{-3}$		2.6×10^{-8}
to nuclear magneton ratio	μ_μ/μ_N	$-8.890\,596\,98(23)$		2.6×10^{-8}
muon magnetic moment anomaly $\lvert\mu_\mu\rvert/(e\hbar/2m_\mu) - 1$	α_μ	$1.165\,919\,81(62)\times10^{-3}$		5.3×10^{-7}
muon g-factor $-2(1 + \alpha_\mu)$	g_μ	$-2.002\,331\,8396(12)$		6.2×10^{-10}
muon-proton magnetic moment ratio	μ_μ/μ_p	$-3.183\,345\,118(89)$		2.8×10^{-8}
Tau, τ^-				
tau mass[6]	m_τ	$3.167\,77(52)\times10^{-27}$	kg	1.6×10^{-4}
in u, $m_\tau = A_r(\tau)$ u (tau relative atomic mass times u)		$1.907\,68(31)$	u	1.6×10^{-4}
energy equivalent	$m_\tau c^2$	$2.847\,05(46)\times10^{-10}$	J	1.6×10^{-4}
in MeV		$1776.99(29)$	MeV	1.6×10^{-4}
tau-electron mass ratio	m_τ/m_e	$3477.48(57)$		1.6×10^{-4}
tau-muon mass ratio	m_τ/m_μ	$16.8183(27)$		1.6×10^{-4}
tau-proton mass ratio	m_τ/m_p	$1.893\,90(31)$		1.6×10^{-4}
tau-neutron mass ratio	m_τ/m_n	$1.891\,29(31)$		1.6×10^{-4}
tau molar mass $N_A m_\tau$	$M(\tau)$, M_τ	$1.907\,68(31)\times10^{-3}$	kg mol^{-1}	1.6×10^{-4}
tau Compton wavelength $h/m_\tau c$	$\lambda_{C,\tau}$	$0.697\,72(11)\times10^{-15}$	m	1.6×10^{-4}
$\lambda_{C,\tau}/2\pi$	$\bar{\lambda}_{C,\tau}$	$0.111\,046(18)\times10^{-15}$	m	1.6×10^{-4}

Quantity	Symbol	Numerical value	Unit	Relative std. uncert. u_r
Proton, p				
proton mass	m_p	$1.672\,621\,71(29)\times10^{-27}$	kg	1.7×10^{-7}
in u, $m_p = A_r(p)$ u (proton relative atomic mass times u)		$1.007\,276\,466\,88(13)$	u	1.3×10^{-10}
energy equivalent	m_pc^2	$1.503\,277\,43(26)\times10^{-10}$	J	1.7×10^{-7}
in MeV		$938.272\,029(80)$	MeV	8.6×10^{-8}
proton-electron mass ratio	m_p/m_e	$1836.152\,672\,61(85)$		4.6×10^{-10}
proton-muon mass ratio	m_p/m_μ	$8.880\,243\,33(23)$		2.6×10^{-8}
proton-tau mass ratio	m_p/m_τ	$0.528\,012(86)$		1.6×10^{-4}
proton-neutron mass ratio	m_p/m_n	$0.998\,623\,478\,72(58)$		5.8×10^{-10}
proton charge to mass quotient	e/m_p	$9.578\,833\,76(82)\times10^{7}$	C kg^{-1}	8.6×10^{-8}
proton molar mass N_Am_p	$M(p)$, M_p	$1.007\,276\,466\,88(13)\times10^{-3}$	kg mol^{-1}	1.3×10^{-10}
proton Compton wavelength h/m_pc	$\lambda_{C,p}$	$1.321\,409\,8555(88)\times10^{-15}$	m	6.7×10^{-9}
$\lambda_{C,p}/2\pi$	$\bar{\lambda}_{C,P}$	$0.210\,308\,9104(14)\times10^{-15}$	m	6.7×10^{-9}
proton rms charge radius	R_p	$0.8750(68)\times10^{-15}$	m	7.8×10^{-3}
proton magnetic moment	μ_p	$1.410\,606\,71(12)\times10^{-26}$	J T^{-1}	8.7×10^{-8}
to Bohr magneton ratio	μ_p/μ_B	$1.521\,032\,206(15)\times10^{-3}$		1.0×10^{-8}
to nuclear magneton ratio	μ_p/μ_N	$2.792\,847\,351(28)$		1.0×10^{-8}
proton *g*-factor $2\mu_p/\mu_N$	g_p	$5.585\,694\,701(56)$		1.0×10^{-8}
proton-neutron magnetic moment ratio	μ_p/μ_n	$-1.459\,898\,05(34)$		2.4×10^{-7}
shielded proton magnetic moment (H_2O, sphere, 25°C)	μ'_P	$1.410\,570\,47(12)\times10^{-26}$	J T^{-1}	8.7×10^{-8}
to Bohr magneton ratio	μ'_P/μ_B	$1.520\,993\,132(16)\times10^{-3}$		1.1×10^{-8}
to nuclear magneton ratio	μ'_P/μ_N	$2.792\,775\,604(30)$		1.1×10^{-8}
proton magnetic shielding correction $1-\mu'_P/\mu_P$ (H_2O, sphere, 25°C)	σ'_P	$25.689(15)\times10^{-6}$		5.7×10^{-4}
proton gyromagnetic ratio $2\mu_p/\hbar$	γ_P	$2.675\,222\,05(23)\times10^{8}$	s^{-1} T^{-1}	8.6×10^{-8}
	$\gamma_p/2\pi$	$42.577\,4813(37)$	MHz T^{-1}	8.6×10^{-8}
shielded proton gyromagnetic ratio $2\mu'_p/\hbar$ (H_2O, sphere, 25°C)	γ'_P	$2.675\,153\,33(23)\times10^{8}$	s^{-1} T^{-1}	8.6×10^{-8}
	$\gamma'_P/2\pi$	$42.576\,3875(37)$	MHz T^{-1}	8.6×10^{-8}
Neutron, n				
neutron mass	m_n	$1.674\,927\,28(29)\times10^{-27}$	kg	1.7×10^{-7}
in u, $m_n = A_r$ (n) u (neutron relative atomic mass times u)		$1.008\,664\,915\,60(55)$	u	5.5×10^{-10}
energy equivalent	m_nc^2	$1.505\,349\,57(26)\times10^{-10}$	J	1.7×10^{-7}
in MeV		$939.565\,360(81)$	MeV	8.6×10^{-8}
neutron-electron mass ratio	m_n/m_e	$1838.683\,6598(13)$		7.0×10^{-10}
neutron-muon mass ratio	m_n/m_μ	$8.892\,484\,02(23)$		2.6×10^{-8}
neutron-tau mass ratio	m_n/m_τ	$0.528\,740(86)$		1.6×10^{-4}
neutron-proton mass ratio	m_n/m_p	$1.001\,378\,418\,70(58)$		5.8×10^{-10}
neutron molar mass N_Am_n	$M(n)$, M_n	$1.008\,664\,915\,60(55)\times10^{-3}$	kg mol^{-1}	5.5×10^{-10}
neutron Compton wavelength h/m_nc	$\lambda_{C,n}$	$1.319\,590\,9067(88)\times10^{-15}$	m	6.7×10^{-9}
$\lambda_{C,n}/2\pi$	$\bar{\lambda}_{C,n}$	$0.210\,019\,4157(14)\times10^{-15}$	m	6.7×10^{-9}
neutron magnetic moment	μ_n	$-0.966\,236\,45(24)\times10^{-26}$	J T^{-1}	2.5×10^{-7}
to Bohr magneton ratio	μ_n/μ_B	$-1.041\,875\,63(25)\times10^{-3}$		2.4×10^{-7}
to nuclear magneton ratio	μ_n/μ_N	$-1.913\,042\,73(45)$		2.4×10^{-7}
neutron *g*-factor $2\mu_n/\mu_N$	g_n	$-3.826\,085\,46(90)$		2.4×10^{-7}
neutron-electron magnetic moment ratio	μ_n/μ_e	$1.040\,668\,82(25)\times10^{-3}$		2.4×10^{-7}
neutron-proton magnetic moment ratio	μ_n/μ_p	$-0.684\,979\,34(16)$		2.4×10^{-7}
neutron to shielded proton magnetic moment ratio (H_2O, sphere, 25°C)	μ_n/μ'_P	$-0.684\,996\,94(16)$		2.4×10^{-7}
neutron gyromagnetic ratio $2\lvert\mu_n\rvert/\hbar$	γ_n	$1.832\,471\,83(46)\times10^{8}$	s^{-1} T^{-1}	2.5×10^{-7}
	$\gamma_n/2\pi$	$29.164\,6950(73)$	MHz T^{-1}	2.5×10^{-7}
Deuteron, d				
deuteron mass	m_d	$3.343\,583\,35(57)\times10^{-27}$	kg	1.7×10^{-7}
in u, $m_d = A_r(d)$ u (deuteron relative atomic mass times u)		$2.013\,553\,212\,70(35)$	u	1.7×10^{-10}
energy equivalent	m_dc^2	$3.005\,062\,85(51)\times10^{-10}$	J	1.7×10^{-7}
in MeV		$1875.612\,82(16)$	MeV	8.6×10^{-8}
deuteron-electron mass ratio	m_d/m_e	$3670.482\,9652(18)$		4.8×10^{-10}
deuteron-proton mass ratio	m_d/m_p	$1.999\,007\,500\,82(41)$		2.0×10^{-10}
deuteron molar mass N_Am_d	$M(d)$, M_d	$2.013\,553\,212\,70(35)\times10^{-3}$	kg mol^{-1}	1.7×10^{-10}
deuteron rms charge radius	R_d	$2.1394(28)\times10^{-15}$	m	1.3×10^{-3}

Quantity	Symbol	Numerical value	Unit	Relative std. uncert. u_r
deuteron magnetic moment	μ_d	$0.433\,073\,482(38)\times10^{-26}$	J T^{-1}	8.7×10^{-8}
to Bohr magneton ratio	μ_d/μ_B	$0.466\,975\,4567(50)\times10^{-3}$		1.1×10^{-8}
to nuclear magneton ratio	μ_d/μ_N	0.857 438 2329(92)		1.1×10^{-8}
deuteron-electron magnetic moment ratio	μ_d/μ_e	$-4.664\,345\,548(50)\times10^{-4}$		1.1×10^{-8}
deuteron-proton magnetic moment ratio	μ_d/μ_p	0.307 012 2084(45)		1.5×10^{-8}
deuteron-neutron magnetic moment ratio	μ_d/μ_n	−0.448 206 52(11)		2.4×10^{-7}
Helion, h				
helion mass[5]	m_h	$5.006\,412\,14(86)\times10^{-27}$	kg	1.7×10^{-7}
in u, $m_h = A_r(h)$ u (helion relative atomic mass times u)		3.014 932 2434(58)	u	1.9×10^{-9}
energy equivalent	m_hc^2	$4.499\,538\,84(77)\times10^{-10}$	J	1.7×10^{-7}
in MeV		2808.391 42(24)	MeV	8.6×10^{-8}
helion-electron mass ratio	m_h/m_e	5495.885 269(11)		2.0×10^{-9}
helion-proton mass ratio	m_h/m_p	2.993 152 6671(58)		1.9×10^{-9}
helion molar mass N_Am_h	$M(h)$, M_h	$3.014\,932\,2434(58)\times10^{-3}$	kg mol^{-1}	1.9×10^{-9}
shielded helion magnetic moment (gas, sphere, 25°C)	μ'_h	$-1.074\,553\,024(93)\times10^{-26}$	J T^{-1}	8.7×10^{-8}
to Bohr magneton ratio	μ'_h/μ_B	$-1.158\,671\,474(14)\times10^{-3}$		1.2×10^{-8}
to nuclear magneton ratio	μ'_h/μ_N	−2.127 497 723(25)		1.2×10^{-8}
shielded helion to proton magnetic moment ratio (gas, sphere, 25°C)	μ'_h/μ_p	−0.761 766 562(12)		1.5×10^{-8}
shielded helion to shielded proton magnetic moment ratio (gas/H_2O, spheres, 25°C)	μ'_h/μ'_p	−0.761 786 1313(33)		4.3×10^{-9}
shielded helion gyromagnetic ratio $2\lvert\mu'_h\rvert\hbar$ (gas, sphere, 25°C)	γ'_h	$2.037\,894\,70(18)\times10^{8}$	s^{-1} T^{-1}	8.7×10^{-8}
	$\gamma'_h/2\pi$	32.434 1015(28)	MHz T^{-1}	8.7×10^{-8}
Alpha particle, α				
alpha particle mass	m_α	$6.644\,6565(11)\times10^{-27}$	kg	1.7×10^{-7}
in u, $m_\alpha = A_r(\alpha)$ u (alpha particle relative atomic mass times u)		4.001 506 179 149(56)	u	1.4×10^{-11}
energy equivalent	$m_\alpha c^2$	$5.971\,9194(10)\times10^{-10}$	J	1.7×10^{-7}
in MeV		3727.379 17(32)	MeV	8.6×10^{-8}
alpha particle to electron mass ratio	m_α/m_e	7294.299 5363(32)		4.4×10^{-10}
alpha particle to proton mass ratio	m_α/m_p	3.972 599 689 07(52)		1.3×10^{-10}
alpha particle molar mass N_Am_α	$M(\alpha)$, M_α	$4.001\,506\,179\,149(56)\times10^{-3}$	kg mol^{-1}	1.4×10^{-11}
Physico-Chemical				
Avogadro constant	N_A, L	$6.022\,1415(10)\times10^{23}$	mol^{-1}	1.7×10^{-7}
atomic mass constant $m_u = (1/12)m(^{12}C) = 1\text{ u} = 10^{-3}\text{ kg mol}^{-1}/N_A$	m_u	$1.660\,538\,86(28)\times10^{-27}$	kg	1.7×10^{-7}
energy equivalent	m_uc^2	$1.492\,417\,90(26)\times10^{-10}$	J	1.7×10^{-7}
in MeV		931.494 043(80)	MeV	8.6×10^{-8}
Faraday constant[7] N_Ae	F	96 485.3383(83)	C mol^{-1}	8.6×10^{-8}
molar Planck constant	N_Ah	$3.990\,312\,716(27)\times10^{-10}$	J s mol^{-1}	6.7×10^{-9}
	N_Ahc	0.119 626 565 72(80)	J m mol^{-1}	6.7×10^{-9}
molar gas constant	R	8.314 472(15)	J mol^{-1} K^{-1}	1.7×10^{-6}
Boltzmann constant R/N_A	k	$1.380\,6505(24)\times10^{-23}$	J K^{-1}	1.8×10^{-6}
in eV K^{-1}		$8.617\,343(15)\times10^{-5}$	eV K^{-1}	1.8×10^{-6}
	k/h	$2.083\,6644(36)\times10^{10}$	Hz K^{-1}	1.7×10^{-6}
	k/hc	69.503 56(12)	m^{-1} K^{-1}	1.7×10^{-6}
molar volume of ideal gas RT/p				
$T = 273.15$ K, $p = 101.325$ kPa	V_m	$22.413\,996(39)\times10^{-3}$	m^3 mol^{-1}	1.7×10^{-6}
Loschmidt constant N_A/V_m	n_0	$2.686\,7773(47)\times10^{25}$	m^{-3}	1.8×10^{-6}
$T = 273.15$ K, $p = 100$ kPa	V_m	$22.710\,981(40)\times10^{-3}$	m^3 mol^{-1}	1.7×10^{-6}
Sackur-Tetrode constant (absolute entropy constant)[8] $5/2 + \ln[(2\pi m_ukT_1/h^2)^{3/2}kT_1/p_0]$				
$T_1 = 1$ K, $p_0 = 100$ kPa	S_0/R	−1.151 7047(44)		3.8×10^{-6}
$T_1 = 1$ K, $p_0 = 101.325$ kPa		−1.164 8677(44)		3.8×10^{-6}
Stefan-Boltzmann constant $(\pi^2/60)k^4/\hbar^3c^2$	σ	$5.670\,400(40)\times10^{-8}$	W m^{-2} K^{-4}	7.0×10^{-6}
first radiation constant $2\pi hc^2$	c_1	$3.741\,771\,38(64)\times10^{-16}$	W m^2	1.7×10^{-7}
first radiation constant for spectral radiance $2hc^2$	c_{1L}	$1.191\,042\,82(20)\times10^{-16}$	W m^2 sr^{-1}	1.7×10^{-7}
second radiation constant hc/k	c_2	$1.438\,7752(25)\times10^{-2}$	m K	1.7×10^{-6}
Wien displacement law constant $b = \lambda_{max}T = c_2/4.965\,114\,231\ldots$	b	$2.897\,7685(51)\times10^{-3}$	m K	1.7×10^{-6}

[1] See the "Adopted values" table for the conventional value adopted internationally for realizing representations of the volt using the Josephson effect.

[2] See the "Adopted values" table for the conventional value adopted internationally for realizing representations of the ohm using the quantum Hall effect.

[3] Value recommended by the Particle Data Group (Hagiwara *et al.*, 2002).

[4] Based on the ratio of the masses of the W and Z bosons m_W/m_Z recommended by the Particle Data Group (Hagiwara et al., 2002). The value for $\sin^2\theta_W$ they recommend, which is based on a particular variant of the modified minimal subtraction ($\overline{\text{MS}}$) scheme, is $\sin^2\hat{\theta}_W(M_Z) = 0.231\ 24(24)$.

[5] The helion, symbol h, is the nucleus of the ^{3}He atom.

[6] This and all other values involving m_τ are based on the value of $m_\tau c^2$ in MeV recommended by the Particle Data Group (Hagiwara et al., 2002), but with a standard uncertainty of 0.29 MeV rather than the quoted uncertainty of −0.26 MeV, +0.29 MeV.

[7] The numerical value of F to be used in coulometric chemical measurements is 96 485.336(16) [1.7×10^{-7}] when the relevant current is measured in terms of representations of the volt and ohm based on the Josephson and quantum Hall effects and the internationally adopted conventional values of the Josephson and von Klitzing constants K_{J-90} and R_{K-90} given in the "Adopted values" table.

[8] The entropy of an ideal monoatomic gas of relative atomic mass A_r is given by $S = S_0 + (3/2)R \ln A_r - R \ln(p/p_0) + (5/2)R \ln(T/\text{K})$.

TABLE III. Internationally Adopted Values of Various Quantities

Quantity	Symbol	Numerical value	Unit	Relative std. uncert. u_r
molar mass of ^{12}C	$M(^{12}\text{C})$	12×10^{-3}	kg mol^{-1}	(exact)
molar mass constant $M(^{12}\text{C})/12$	M_u	1×10^{-3}	kg mol^{-1}	(exact)
conventional value of Josephson constant	K_{J-90}	483 597.9	GHz V^{-1}	(exact)
conventional value of von Klitzing constant	R_{K-90}	25 812.807	Ω	(exact)
standard atmosphere		101 325	Pa	(exact)
standard acceleration of gravity	g_n	9.806 65	m s^{-2}	(exact)

TABLE IV. The Values of Some Energy Equivalents Derived From the Relations $E = mc^2 = hc/\lambda = h\nu = kT$, and Based on the 2002 CODATA Adjustment of the Values of the Constants

1 eV = (e/C) J, 1 u = $m_u = (1/12)m(^{12}\text{C}) = 10^{-3}$ kg mol$^{-1}/N_A$, and $E_h = 2R_\infty hc = \alpha^2 m_e c^2$ is the Hartree Energy (hartree)

	Relevant unit			
	J	kg	m^{-1}	Hz
1 J	(1 J) = 1 J	(1 J)/c^2 =1.112 650 056 ×10^{-17} kg	(1 J)/hc = 5.034 117 20(86)×10^{24} m^{-1}	(1 J)/h =1.509 190 37(26)×10^{33} Hz
1 kg	(1 kg)c^2 = 8.987 551 787 ×10^{16} J	(1 kg) = 1kg	(1 kg)c/h = 4.524 438 91(77)×10^{41} m^{-1}	(1 kg)c^2/h = 1.356 392 66(23)×10^{50} Hz
1 m^{-1}	(1 m^{-1})hc = 1.986 445 61(34)×10^{-25} J	(1 m^{-1})h/c = 2.210 218 81(38)×10^{-42} kg	(1 m^{-1}) = 1 m^{-1}	(1 m^{-1})c = 299 792 458 Hz
1 Hz	(1 Hz)h = 6.626 0693(11) ×10^{-34} J	(1 Hz)h/c^2 = 7.372 4964(13)×10^{-51} kg	(1 Hz)/c = 3.335 640 952×10^{-9} m^{-1}	(1 Hz) = 1 Hz
1 K	(1 K)k = 1.380 6505(24) ×10^{-23} J	(1 K)k/c^2 =1.536 1808(27) ×10^{-40} kg	(1 K)k/hc = 69.503 56(12) m^{-1}	(1 K)k/h = 2.083 6644(36)×10^{10} Hz
1 eV	(1 eV) =1.602 176 53(14) ×10^{-19} J	(1 eV)/c^2 = 1.782 661 81(15)×10^{-36} kg	(1 eV)/hc = 8.065 544 45(69)×10^{5} m^{-1}	(1 eV)/h = 2.417 989 40(21)×10^{14} Hz
1 u	(1 u)c^2 = 1.492 417 90(26) ×10^{-10} J	(1 u) = 1.660 538 86(28)×10^{-27} kg	(1 u)c/h = 7.513 006 608(50) ×10^{14} m^{-1}	(1 u)c^2/h = 2.252 342 718(15)×10^{23} Hz
1 E_h	(1 E_h) = 4.359 744 17(75)×10^{-18} J	(1 E_h)/c^2 = 4.850 869 60(83) ×10^{-35} kg	(1 E_h)/hc = 2.194 746 313 705(15)×10^{7} m^{-1}	(1 E_h)/h = 6.579 683 920 721(44)×10^{15} Hz

TABLE V. The Values of Some Energy Equivalents Derived From the Relations $E = mc^2 = hc/\lambda = h\nu = kT$, and Based on the 2002 CODATA Adjustment of the Values of the Constants

1 eV = (e/C) J, 1 u = $m_u = (1/12)m(^{12}\text{C}) = 10^{-3}$ kg mol$^{-1}/N_A$, and $E_h = 2R_\infty hc = \alpha^2 m_e c^2$ is the Hartree Energy (hartree)

	Relevant unit			
	K	eV	u	E_h
1 J	(1 J)/k = 7.242 963(13)×10^{22} K	(1 J) = 6.241 509 47(53)×10^{18} eV	(1 J)/c^2 =6.700 5361(11)×10^{9} u	(1 J) = 2.293 712 57(39) ×10^{17} E_h
1 kg	(1 kg)c^2/k =6.509 650(11) ×10^{39} K	(1 kg)c^2 = 5.609 588 96(48)×10^{35} eV	(1 kg) = 6.022 1415(10)×10^{26} u	(1 kg)c^2 = 2.061 486 05(35)×10^{34} E_h
1 m^{-1}	(1 m^{-1})hc/k = 1.438 7752(25)×10^{-2} K	(1 m^{-1})hc = 1.239 841 91(11)×10^{-6} eV	(1 m^{-1})h/c = 1.331 025 0506(89) ×10^{-15} u	(1 m^{-1})hc = 4.556 335 252 760(30) ×10^{-8} E_h
1 Hz	(1 Hz)h/k = 4.799 2374(84)×10^{-11} K	(1 Hz)h = 4.135 667 43(35)×10^{-15} eV	(1 Hz)h/c^2 = 4.439 821 667(30)×10^{-24} u	(1 Hz)h = 1.519 829 846 006(10)×10^{-16} E_h
1 K	(1 K) = 1 K	(1 K)k = 8.617 343(15)×10^{-5} eV	(1 K)k/c^2 =9.251 098(16)×10^{-14} u	(1 K)k = 3.166 8153(55)×10^{-6} E_h
1 eV	(1 eV)/k = 1.160 4505(20)×10^{4} K	(1 eV) = 1 eV	(1 eV)/c^2 = 1.073 544 171(92)×10^{-9} u	(1 eV) = 3.674 932 45(31) ×10^{-2} E_h
1 u	(1 u)c^2/k = 1.080 9527(19)×10^{13} K	(1 u)c^2 = 931.494 043(80)×10^{6} eV	(1 u) = 1 u	(1 u)c^2 = 3.423 177 686(23) ×10^{7} E_h
1 E_h	(1 E_h)/k = 3.157 7465(55) ×10^{5} K	(1 E_h) = 27.211 3845(23) eV	(1 E_h)/c^2 = 2.921 262 323(19)×10^{-8} u	(1 E_h) = 1 E_h

FUNDAMENTAL PHYSICAL CONSTANTS — FREQUENTLY USED CONSTANTS

Quantity	Symbol	Value	Unit	Relative std. uncert. u_r
speed of light in vacuum	c, c_0	299 792 458	$m\ s^{-1}$	(exact)
magnetic constant	μ_0	$4\pi \times 10^{-7}$	$N\ A^{-2}$	
		$= 12.566\ 370\ 614\ldots \times 10^{-7}$	$N\ A^{-2}$	(exact)
electric constant $1/\mu_0 c^2$	ε_0	$8.854\ 187\ 817\ldots \times 10^{-12}$	$F\ m^{-1}$	(exact)
Newtonian constant of gravitation	G	$6.6742(10) \times 10^{-11}$	$m^3\ kg^{-1}\ s^{-2}$	1.5×10^{-4}
Plank constant	h	$6.626\ 0693(11) \times 10^{-34}$	J s	1.7×10^{-7}
$h/2\pi$	$\hbar$	$1.054\ 571\ 68(18) \times 10^{-34}$	J s	1.7×10^{-7}
elementary charge	e	$1.602\ 176\ 53(14) \times 10^{-19}$	C	8.5×10^{-8}
magnetic flux quantum $h/2e$	ϕ_0	$2.067\ 833\ 72(18) \times 10^{-15}$	Wb	8.5×10^{-8}
conductance quantum $2e^2/h$	G_0	$7.748\ 091\ 733(26) \times 10^{-5}$	S	3.3×10^{-9}
electron mass	m_e	$9.109\ 3826(16) \times 10^{-31}$	kg	1.7×10^{-7}
proton mass	m_p	$1.672\ 621\ 71(29) \times 10^{-27}$	kg	1.7×10^{-7}
proton-electron mass ratio	m_p/m_e	1836.152 672 61(85)		4.6×10^{-10}
fine-structure constant $e^2/4\pi\varepsilon_0\hbar c$	α	$7.297\ 352\ 568(24) \times 10^{-3}$		3.3×10^{-9}
inverse fine-structure constant	α^{-1}	137.035 999 11(46)		3.3×10^{-9}
Rydberg constant $\alpha^2 m_e c/2h$	R_∞	10 973 731.568 525(73)	m^{-1}	6.6×10^{-12}
Avogadro constant	N_A, L	$6.022\ 1415(10) \times 10^{23}$	mol^{-1}	1.7×10^{-7}
Faraday constant $N_A e$	F	96 485.3383(83)	$C\ mol^{-1}$	8.6×10^{-8}
molar gas constant	R	8.314 472(15)	$J\ mol^{-1}\ K^{-1}$	1.7×10^{-6}
Boltzmann constant R/N_A	k	$1.380\ 6505(24) \times 10^{-23}$	$J\ K^{-1}$	1.8×10^{-6}
Stefan-Boltzmann constant $(\pi^2/60)k^4/\hbar^3 c^2$	σ	$5.670\ 400(40) \times 10^{-8}$	$W\ m^{-2}\ K^{-4}$	7.0×10^{-6}
		Non-SI units accepted for use with the SI		
electron volt: (e/C) J	eV	$1.602\ 176\ 53(14) \times 10^{-19}$	J	8.5×10^{-8}
(unified) atomic mass unit 1 u= $m_u = {}^1/_{12}\, m(^{12}C) = 10^{-3}$ kg mol$^{-1}/N_A$	u	$1.660\ 538\ 86(28) \times 10^{-27}$	kg	1.7×10^{-7}