Fundamental Physical Constants

This booklet gives the latest 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. This, the 1998 set, replaces its immediate predecessor recommended by CODATA in 1986 and takes into account all of the data available through 31 December 1998.

The values given in these tables are a self-consistent set from a least squares evaluation produced by P J Mohr and B N Taylor (J. Phys. Chem. Ref. Data, **28**(6), 1713–1852 (1999)). Energy conversion factors (these are apparent from their units) have been included in the table immediately below the appropriate quantities. The figures in parentheses () in the 'value' column represent the best estimates of the standard deviation uncertainties in the last two digits quoted, based on internal consistency. The International System of Units (SI) have been employed throughout this booklet.

CODATA was established in 1966 as an interdisciplinary committee of the International Council of Scientific Unions (ICSU), now the International Council for Science. It seeks to improve the quality, reliability, processing, management, and accessibility of data of importance to science and technology. In 1969 the Task Group on Fundamental Constants was set up to periodically review all the relevant data available at a given time, and to produce a self-consistent set of basic constants and energy conversion factors for international use.

The National Physical Laboratory (NPL) has the primary responsibility in the UK for the determination of the key fundamental constants. For further information contact the NPL Helpline.

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_r
Universal				
speed of light in vacuum	c, c_0	$299\,792\,458$	$\mathrm{m \cdot s^{-1}}$	(exact)
magnetic constant	μ_0	$4\pi \times 10^{-7}$	$\mathrm{N \cdot A^{-2}}$	
		$= 12.566\,370\,614\ldots \times 10^{-7}$	$\mathrm{N \cdot A^{-2}}$	(exact)
electric constant $1/\mu_0 c^2$	ϵ_0	$8.854\,187\,817\ldots \times 10^{-12}$	$\mathrm{F \cdot m^{-1}}$	(exact)
characteristic impedance of vacuum $\sqrt{\mu_0/\epsilon_0} = \mu_0 c$	Z_0	$376.730\,313\,461\ldots$	Ω	(exact)
Newtonian constant of gravitation	G	$6.673(10) \times 10^{-11}$	$\mathrm{m^3 \cdot kg^{-1} \cdot s^{-2}}$	1.5×10^{-3}
	$G/\hbar c$	$6.707(10) \times 10^{-39}$	$(\mathrm{GeV}/c^2)^{-2}$	1.5×10^{-3}
Planck constant	h	$6.626\,068\,76(52) \times 10^{-34}$	$\mathrm{J \cdot s}$	7.8×10^{-8}
in $\mathrm{eV \cdot s}$		$4.135\,667\,27(16) \times 10^{-15}$	$\mathrm{eV \cdot s}$	3.9×10^{-8}
$h/2\pi$	$\hbar$	$1.054\,571\,596(82) \times 10^{-34}$	$\mathrm{J \cdot s}$	7.8×10^{-8}
in $\mathrm{eV \cdot s}$		$6.582\,118\,89(26) \times 10^{-16}$	$\mathrm{eV \cdot s}$	3.9×10^{-8}
Planck mass $(\hbar c/G)^{1/2}$	m_p	$2.1767(16) \times 10^{-8}$	kg	7.5×10^{-4}
Planck length $\hbar/m_\mathrm{p}c = (\hbar G/c^3)^{1/2}$	l_p	$1.6160(12) \times 10^{-35}$	m	7.5×10^{-4}
Planck time $l_\mathrm{p}/c = (\hbar G/c^5)^{1/2}$	t_p	$5.3906(40) \times 10^{-44}$	s	7.5×10^{-4}
Electromagnetic				
elementary charge	e	$1.602\,176\,462(63) \times 10^{-19}$	C	3.9×10^{-8}
	e/h	$2.417\,989\,491(95) \times 10^{14}$	$\mathrm{A \cdot J^{-1}}$	3.9×10^{-8}
magnetic flux quantum $h/2e$	Φ_0	$2.067\,833\,636(81) \times 10^{-15}$	Wb	3.9×10^{-8}
conductance quantum $2e^2/h$	G_0	$7.748\,091\,696(28) \times 10^{-5}$	S	3.7×10^{-9}
inverse of conductance quantum	G_0^{-1}	$12\,906.403\,786(47)$	Ω	3.7×10^{-9}
Josephson constant[a] $2e/h$	K_J	$483\,597.898(19) \times 10^{9}$	$\mathrm{Hz \cdot V^{-1}}$	3.9×10^{-8}
von Klitzing constant[b] $h/e^2 = \mu_0 c/2\alpha$	R_K	$25\,812.807\,572(95)$	Ω	3.7×10^{-9}
Bohr magneton $e\hbar/2m_\mathrm{e}$	μ_B	$927.400\,899(37) \times 10^{-26}$	$\mathrm{J \cdot T^{-1}}$	4.0×10^{-8}
in $\mathrm{eV \cdot T^{-1}}$		$5.788\,381\,749(43) \times 10^{-5}$	$\mathrm{eV \cdot T^{-1}}$	7.3×10^{-9}
	μ_B/h	$13.996\,246\,24(56) \times 10^{9}$	$\mathrm{Hz \cdot T^{-1}}$	4.0×10^{-8}
	μ_B/hc	$46.686\,4521(19)$	$\mathrm{m^{-1} \cdot T^{-1}}$	4.0×10^{-8}

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

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

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_r
	μ_B/k	$0.671\,7131(12)$	$\mathrm{K \cdot T^{-1}}$	1.7×10^{-6}
nuclear magneton $e\hbar/2m_\mathrm{p}$	μ_N	$5.050\,783\,17(20) \times 10^{-27}$	$\mathrm{J \cdot T^{-1}}$	4.0×10^{-8}
in $\mathrm{eV \cdot T^{-1}}$		$3.152\,451\,238(24) \times 10^{-8}$	$\mathrm{eV \cdot T^{-1}}$	7.6×10^{-9}
	μ_N/h	$7.622\,593\,96(31)$	$\mathrm{MHz \cdot T^{-1}}$	4.0×10^{-8}
	μ_N/hc	$2.542\,623\,66(10) \times 10^{-2}$	$\mathrm{m^{-1} \cdot T^{-1}}$	4.0×10^{-8}
	μ_N/k	$3.658\,2638(64) \times 10^{-4}$	$\mathrm{K \cdot T^{-1}}$	1.7×10^{-6}

Atomic and Nuclear

General

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_r
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	α	$7.297\,352\,533(27) \times 10^{-3}$		3.7×10^{-9}
inverse fine-structure constant	α^{-1}	$137.035\,999\,76(50)$		3.7×10^{-9}
Rydberg constant $\alpha^2 m_\mathrm{e} c/2h$	R_∞	$10\,973\,731.568\,549(83)$	$\mathrm{m^{-1}}$	7.6×10^{-12}
	$R_\infty c$	$3.289\,841\,960\,368(25) \times 10^{15}$	Hz	7.6×10^{-12}
	$R_\infty hc$	$2.179\,871\,90(17) \times 10^{-18}$	J	7.8×10^{-8}
$R_\infty hc$ in eV		$13.605\,691\,72(53)$	eV	3.9×10^{-8}
Bohr radius $\alpha/4\pi R_\infty = 4\pi\epsilon_0\hbar^2/m_\mathrm{e}e^2$	a_0	$0.529\,177\,2083(19) \times 10^{-10}$	m	3.7×10^{-9}
Hartree energy $e^2/4\pi\epsilon_0 a_0 = 2R_\infty hc = \alpha^2 m_\mathrm{e} c^2$	E_h	$4.359\,743\,81(34) \times 10^{-18}$	J	7.8×10^{-8}
in eV		$27.211\,3834(11)$	eV	3.9×10^{-8}
quantum of circulation	$h/2m_\mathrm{e}$	$3.636\,947\,516(27) \times 10^{-4}$	$\mathrm{m^2 \cdot s^{-1}}$	7.3×10^{-9}
	h/m_e	$7.273\,895\,032(53) \times 10^{-4}$	$\mathrm{m^2 \cdot s^{-1}}$	7.3×10^{-9}

Electroweak

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_r
Fermi coupling constant[c]	$G_\mathrm{F}/(\hbar c)^3$	$1.166\,39(1) \times 10^{-5}$	$\mathrm{GeV^{-2}}$	8.6×10^{-6}
weak mixing angle[d] Θ_W (on-shell scheme) $\sin^2\Theta_\mathrm{W} = s^2_\mathrm{W} \equiv 1 - (m_\mathrm{W}/m_\mathrm{Z})^2$	$\sin^2\Theta_\mathrm{W}$	$0.2224(19)$		8.7×10^{-3}

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[c] Value recommended by the Particle Data Group, Caso et al., Eur. Phys. J. C **3**(1–4), 1–794(1998)

[d] Based on the ratio of the masses of the W and M bosons $m_\mathrm{W}/m_\mathrm{Z}$ recommended by the Particle Data Group (Caso et al., 1998). The value for $\sin^2\Theta_\mathrm{W}$ they recommend, which is based on a particular variant of the modified minimal subtraction ($\overline{\mathrm{MS}}$) scheme, is $\sin^2\hat{\Theta}_\mathrm{W}(M_\mathrm{Z}) = 0.231\,24(24)$.

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_r
Electron, e^-				
electron mass	m_e	$9.109\,381\,88(72) \times 10^{-31}$	kg	7.9×10^{-8}
in u, $m_\mathrm{e} = A_\mathrm{r}(\mathrm{e})\mathrm{u}$ (electron relative mass times u)		$5.485\,799\,110(12) \times 10^{-4}$	u	2.1×10^{-9}
energy equivalent	$m_\mathrm{e}c^2$	$8.187\,104\,14(64) \times 10^{-14}$	J	7.9×10^{-8}
in MeV		$0.510\,998\,902(21)$	MeV	4.0×10^{-8}
electron-muon mass ratio	m_e/m_μ	$4.836\,332\,10(15) \times 10^{-3}$		3.0×10^{-8}
electron-tau mass ratio	m_e/m_τ	$2.875\,55(47) \times 10^{-4}$		1.6×10^{-4}
electron-proton mass ratio	$m_\mathrm{e}/m_\mathrm{p}$	$5.446\,170\,232(12) \times 10^{-4}$		2.1×10^{-9}
electron-neutron mass ratio	$m_\mathrm{e}/m_\mathrm{n}$	$5.438\,673\,462(12) \times 10^{-4}$		2.2×10^{-9}
electron-deuteron mass ratio	$m_\mathrm{e}/m_\mathrm{d}$	$2.724\,437\,1170(58) \times 10^{-4}$		2.1×10^{-9}
electron to alpha particle mass ratio	m_e/m_α	$1.370\,933\,5611(29) \times 10^{-4}$		2.1×10^{-9}
electron charge to mass quotient	$-e/m_\mathrm{e}$	$-1.758\,820\,174(71) \times 10^{11}$	$\mathrm{C \cdot kg^{-1}}$	4.0×10^{-8}
electron molar mass $N_\mathrm{A}m_\mathrm{e}$	$M(\mathrm{e}), M_\mathrm{e}$	$5.485\,799\,110(12) \times 10^{-7}$	$\mathrm{kg \cdot mol^{-1}}$	2.1×10^{-9}
Compton wavelength $h/m_\mathrm{e}c$	λ_C	$2.426\,310\,215(18) \times 10^{-12}$	m	7.3×10^{-9}
$\lambda_\mathrm{C}/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\lambdabar_\mathrm{C}$	$386.159\,2642(28) \times 10^{-15}$	m	7.3×10^{-9}
classical electron radius $\alpha^2 a_0$	r_e	$2.817\,940\,285(31) \times 10^{-15}$	m	1.1×10^{-8}
Thomson cross section $(8\pi/3)r_\mathrm{e}^2$	σ_e	$0.665\,245\,854(15) \times 10^{-28}$	$\mathrm{m^2}$	2.2×10^{-8}
electron magnetic moment	μ_e	$-928.476\,362(37) \times 10^{-26}$	$\mathrm{J \cdot T^{-1}}$	4.0×10^{-8}
to Bohr magneton ratio	$\mu_\mathrm{e}/\mu_\mathrm{B}$	$-1.001\,159\,652\,1869(41)$		4.1×10^{-12}
to nuclear magneton ratio	$\mu_\mathrm{e}/\mu_\mathrm{N}$	$-1\,838.281\,9660(39)$		2.1×10^{-9}
electron magnetic moment anomaly $\lvert\mu_\mathrm{e}\rvert/\mu_\mathrm{B} - 1$	a_e	$1.159\,652\,1869(41) \times 10^{-3}$		3.5×10^{-9}
electron g-factor $-2(1 + a_\mathrm{e})$	g_e	$-2.002\,319\,304\,3737(82)$		4.1×10^{-12}
electron-muon magnetic moment ratio	μ_e/μ_μ	$206.766\,9720(63)$		3.0×10^{-8}
electron-proton magnetic moment ratio	$\mu_\mathrm{e}/\mu_\mathrm{p}$	$-\ 658.210\,6875(66)$		1.0×10^{-8}
electron to shielded proton magnetic moment ratio (H_2O, sphere, 25 °C)	$\mu_\mathrm{e}/\mu'_\mathrm{p}$	$-\ 658.227\,5954(71)$		1.1×10^{-8}
electron-neutron magnetic moment ratio	$\mu_\mathrm{e}/\mu_\mathrm{n}$	$960.920\,50(23)$		2.4×10^{-7}
electron-deuteron magnetic moment ratio	$\mu_\mathrm{e}/\mu_\mathrm{d}$	$-2\,143.923\,498(23)$		1.1×10^{-8}
electron to shielded helion magnetic moment ratio (gas, sphere, 25 °C)	$\mu_\mathrm{e}/\mu'_\mathrm{h}$	$864.058\,255(10)$		1.2×10^{-8}

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_r
electron gyromagnetic ratio $2\lvert\mu_e\rvert/\hbar$	γ_e	$1.760\,859\,794(71) \times 10^{11}$	$s^{-1} \cdot T^{-1}$	4.0×10^{-8}
	$\gamma_e/2\pi$	$28\,024.9540(11)$	$MHz \cdot T^{-1}$	4.0×10^{-8}
Muon, μ^-				
muon mass	m_μ	$1.883\,531\,09(16) \times 10^{-28}$	kg	8.4×10^{-8}
in u, $m_\mu = A_r(\mu)u$ (muon relative atomic mass times u)		$0.113\,428\,9168(34)$	u	3.0×10^{-8}
energy equivalent	$m_\mu c^2$	$1.692\,833\,32(14) \times 10^{-11}$	J	8.4×10^{-8}
in MeV		$105.658\,3568(52)$	MeV	4.9×10^{-8}
muon-electron mass ratio	m_μ/m_e	$206.768\,2657(63)$		3.0×10^{-8}
muon-tau mass ratio	m_μ/m_τ	$5.945\,72(97) \times 10^{-2}$		1.6×10^{-4}
muon-proton mass ratio	m_μ/m_p	$0.112\,609\,5173(34)$		3.0×10^{-8}
muon-neutron mass ratio	m_μ/m_n	$0.112\,454\,5079(34)$		3.0×10^{-8}
muon molar mass $N_A m_\mu$	$M(\mu), M_\mu$	$0.113\,428\,9168(34) \times 10^{-3}$	$kg \cdot mol^{-1}$	3.0×10^{-8}
muon Compton wavelength $h/m_\mu c$	$\lambda_{C,\mu}$	$11.734\,441\,97(35) \times 10^{-15}$	m	2.9×10^{-8}
$\lambda_{C,\mu}/2\pi$	$\bar{\lambda}_{C,\mu}$	$1.867\,594\,444(55) \times 10^{-15}$	m	2.9×10^{-8}
muon magnetic moment	μ_μ	$-4.490\,448\,13(22) \times 10^{-26}$	$J \cdot T^{-1}$	4.9×10^{-8}
to Bohr magneton ratio	μ_μ/μ_B	$-4.841\,970\,85(15) \times 10^{-3}$		3.0×10^{-8}
to nuclear magneton ratio	μ_μ/μ_N	$-8.890\,597\,70(27)$		3.0×10^{-8}
muon magnetic moment anomaly $\lvert\mu_\mu\rvert/(e\hbar/2m_\mu) - 1$	a_μ	$1.165\,916\,02(64) \times 10^{-3}$		5.5×10^{-7}
muon g-factor $-2(1 + a_\mu)$	g_μ	$-2.002\,331\,8320(13)$		6.4×10^{-10}
muon-proton magnetic moment ratio	μ_μ/μ_p	$-3.183\,345\,39(10)$		3.2×10^{-8}
Tau, τ^-				
tau mass[e]	m_τ	$3.167\,88(52) \times 10^{-27}$	kg	1.6×10^{-4}
in u, $m_\tau = A_r(\tau)u$ (tau relative atomic mass time u)		$1.907\,74(31)$	u	1.6×10^{-4}
energy equivalent	$m_\tau c^2$	$2.847\,15(46) \times 10^{-10}$	J	1.6×10^{-4}
in MeV		$1\,777.05(29)$	MeV	1.6×10^{-4}
tau-electron mass ratio	m_τ/m_e	$3\,477.60(57)$		1.6×10^{-4}
tau-muon mass ratio	m_τ/m_μ	$16.8188(27)$		1.6×10^{-4}
tau-proton mass ratio	m_τ/m_p	$1.893\,96(31)$		1.6×10^{-4}

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[e] This and all other values involving m_τ are based on the values of $m_\tau c^2$ in MeV recommended by the Particle Data Group (Caso et al., 1998), but with a standard uncertainty of 0.29 MeV rather than the quoted uncertainty of -0.26 MeV, $+0.29$ MeV.

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_r
tau-neutron mass ratio	m_τ/m_n	1.891 35(31)		1.6×10^{-4}
tau molar mass $N_\mathrm{A} m_\tau$	$M(\tau), M_\tau$	$1.907\,74(31) \times 10^{-3}$	$\mathrm{kg \cdot mol^{-1}}$	1.6×10^{-4}
tau Compton wavelength $h/m_\tau c$	$\lambda_{\mathrm{C},\tau}$	$0.697\,70(11) \times 10^{-15}$	m	1.6×10^{-4}
$\lambda_{\mathrm{C},\tau}/2\pi$	$\bar{\lambda}_{\mathrm{C},\tau}$	$0.111\,042(18) \times 10^{-15}$	m	1.6×10^{-4}
Proton, p				
proton mass	m_p	$1.672\,621\,58(13) \times 10^{-27}$	kg	7.9×10^{-8}
in u, $m_\mathrm{p} = A_\mathrm{r}(\mathrm{p})\mathrm{u}$ (proton relative atomic mass times u)		1.007 276 466 88(13)	u	1.3×10^{-10}
energy equivalent	$m_\mathrm{p} c^2$	$1.503\,277\,31(12) \times 10^{-10}$	J	7.9×10^{-8}
in MeV		938.271 998(38)	MeV	4.0×10^{-8}
proton-electron mass ratio	$m_\mathrm{p}/m_\mathrm{e}$	1 836.152 6675(39)		2.1×10^{-9}
proton-muon mass ratio	m_p/m_μ	8.880 244 08(27)		3.0×10^{-8}
proton-tau mass ratio	m_p/m_τ	0.527 994(86)		1.6×10^{-4}
proton-neutron mass ratio	$m_\mathrm{p}/m_\mathrm{n}$	0.998 623 478 55(58)		5.8×10^{-10}
proton charge to mass quotient	e/m_p	$9.578\,834\,08(38) \times 10^{7}$	$\mathrm{C \cdot kg^{-1}}$	4.0×10^{-8}
proton molar mass $N_\mathrm{A} m_\mathrm{p}$	$M(\mathrm{p}), M_\mathrm{p}$	$1.007\,276\,466\,88(13) \times 10^{-3}$	$\mathrm{kg \cdot mol^{-1}}$	1.3×10^{-10}
proton Compton wavelength $h/m_\mathrm{p} c$	$\lambda_{\mathrm{C,p}}$	$1.321\,409\,847(10) \times 10^{-15}$	m	7.6×10^{-9}
$\lambda_{\mathrm{C,p}}/2\pi$	$\bar{\lambda}_{\mathrm{C,p}}$	$0.210\,308\,9089(16) \times 10^{-15}$	m	7.6×10^{-9}
proton magnetic moment	μ_p	$1.410\,606\,633(58) \times 10^{-26}$	$\mathrm{J \cdot T^{-1}}$	4.1×10^{-8}
to Bohr magneton ratio	$\mu_\mathrm{p}/\mu_\mathrm{B}$	$1.521\,032\,203(15) \times 10^{-3}$		1.0×10^{-8}
to nuclear magneton ratio	$\mu_\mathrm{p}/\mu_\mathrm{N}$	2.792 847 337(29)		1.0×10^{-8}
proton g-factor $2\mu_\mathrm{p}/\mu_\mathrm{N}$	g_p	5.585 694 675(57)		1.0×10^{-8}
proton-neutron magnetic moment ratio	$\mu_\mathrm{p}/\mu_\mathrm{n}$	−1.459 898 05(34)		2.4×10^{-7}
shielded proton magnetic moment(H_2O, sphere, 25 ℃)	μ'_p	$1.410\,570\,399(59) \times 10^{-26}$	$\mathrm{J \cdot T^{-1}}$	4.2×10^{-8}
to Bohr magneton ratio	$\mu'_\mathrm{p}/\mu_\mathrm{B}$	$1.520\,993\,132(16) \times 10^{-3}$		1.1×10^{-8}
to nuclear magneton ratio	$\mu'_\mathrm{p}/\mu_\mathrm{N}$	2.792 775 597(31)		1.1×10^{-8}
proton magnetic shielding correction $1 - \mu'_\mathrm{p}/\mu_\mathrm{p}$ (H_2O, sphere, 25 ℃)	σ'_p	$25.687(15) \times 10^{-6}$		5.7×10^{-4}
proton gyromagnetic ratio $2\mu_\mathrm{p}/\hbar$	γ_p	$2.675\,222\,12(11) \times 10^{8}$	$\mathrm{s^{-1} \cdot T^{-1}}$	4.1×10^{-8}
	$\gamma_\mathrm{p}/2\pi$	42.577 4825(18)	$\mathrm{MHz \cdot T^{-1}}$	4.1×10^{-8}
shielded proton gyromagnetic ratio $2\mu'_\mathrm{p}/\hbar$ (H_2O, sphere, 25 ℃)	γ'_p	$2.675\,153\,41(11) \times 10^{8}$	$\mathrm{s^{-1} \cdot T^{-1}}$	4.2×10^{-8}
	$\gamma'_\mathrm{p}/2\pi$	42.576 3888(18)	$\mathrm{MHz \cdot T^{-1}}$	4.2×10^{-8}

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_{r}
Neutron, n				
neutron mass	m_{n}	$1.674\,927\,16(13) \times 10^{-27}$	kg	7.9×10^{-8}
in u, $m_{\mathrm{n}} = A_{\mathrm{r}}(n)\mathrm{u}$ (neutron relative atomic mass times u)		$1.008\,664\,915\,78(55)$	u	5.4×10^{-10}
energy equivalent	$m_{\mathrm{n}}c^2$	$1.505\,349\,46(12) \times 10^{-10}$	J	7.9×10^{-8}
in MeV		$939.565\,330(38)$	MeV	4.0×10^{-8}
neutron-electron mass ratio	$m_{\mathrm{n}}/m_{\mathrm{e}}$	$1\,838.683\,6550(40)$		2.2×10^{-9}
neutron-muon mass ratio	m_{n}/m_{μ}	$8.892\,484\,78(27)$		3.0×10^{-8}
neutron-tau mass ratio	m_{n}/m_{τ}	$0.528\,722(86)$		1.6×10^{-4}
neutron-proton mass ratio	$m_{\mathrm{n}}/m_{\mathrm{p}}$	$1.001\,378\,418\,87(58)$		5.8×10^{-10}
neutron molar mass $N_{\mathrm{A}}m_{\mathrm{n}}$	$M(\mathrm{n}), M_{\mathrm{n}}$	$1.008\,664\,915\,78(55) \times 10^{-3}$	$\mathrm{kg} \cdot \mathrm{mol}^{-1}$	5.4×10^{-10}
neutron Compton wavelength $h/m_{\mathrm{n}}c$	$\lambda_{\mathrm{C,n}}$	$1.319\,590\,898(10) \times 10^{-15}$	m	7.6×10^{-9}
$\lambda_{\mathrm{C,n}}/2\pi$	$\bar{\lambda}_{\mathrm{C,n}}$	$0.210\,019\,4142(16) \times 10^{-15}$	m	7.6×10^{-9}
neutron magnetic moment	μ_{n}	$-0.966\,236\,40(23) \times 10^{-26}$	$\mathrm{J} \cdot \mathrm{T}^{-1}$	2.4×10^{-7}
to Bohr magneton ratio	$\mu_{\mathrm{n}}/\mu_{\mathrm{B}}$	$-1.041\,875\,63(25) \times 10^{-3}$		2.4×10^{-7}
to nuclear magneton ratio	$\mu_{\mathrm{n}}/\mu_{\mathrm{N}}$	$-1.913\,042\,72(45)$		2.4×10^{-7}
neutron g-factor $2\mu_{\mathrm{n}}/\mu_{\mathrm{N}}$	g_{n}	$-3.826\,085\,45(90)$		2.4×10^{-7}
neutron-electron magnetic moment ratio	$\mu_{\mathrm{n}}/\mu_{\mathrm{e}}$	$1.040\,668\,82(25) \times 10^{-3}$		2.4×10^{-7}
neutron-proton magnetic moment ratio	$\mu_{\mathrm{n}}/\mu_{\mathrm{p}}$	$-0.684\,979\,34(16)$		2.4×10^{-7}
neutron to shielded proton magnetic moment ratio (H_2O, sphere, 25 ℃)	$\mu_{\mathrm{n}}/\mu'_{\mathrm{p}}$	$-0.684\,996\,94(16)$		2.4×10^{-7}
neutron gyromagnetic ratio $2\lvert\mu_{\mathrm{n}}\rvert/\hbar$	γ_{n}	$1.832\,471\,88(44) \times 10^{8}$	$\mathrm{s}^{-1} \cdot \mathrm{T}^{-1}$	2.4×10^{-7}
	$\gamma_{\mathrm{n}}/2\pi$	$29.164\,6958(70)$	$\mathrm{MHz} \cdot \mathrm{T}^{-1}$	2.4×10^{-7}
Deutron, d				
deuteron mass	m_{d}	$3.343\,583\,09(26) \times 10^{-27}$	kg	7.9×10^{-8}
in u, $m_{\mathrm{d}} = A_{\mathrm{r}}(\mathrm{d})\mathrm{u}$ (deuteron relative atomic mass times u)		$2.013\,553\,212\,71(35)$	u	1.7×10^{-10}
energy equivalent	$m_{\mathrm{d}}c^2$	$3.005\,062\,62(24) \times 10^{-10}$	J	7.9×10^{-8}
in MeV		$1\,875.612\,762(75)$	MeV	4.0×10^{-8}
deuteron-electron mass ratio	$m_{\mathrm{d}}/m_{\mathrm{e}}$	$3\,670.482\,9550(78)$		2.1×10^{-9}
deuteron-proton mass ratio	$m_{\mathrm{d}}/m_{\mathrm{p}}$	$1.999\,007\,500\,83(41)$		2.0×10^{-10}
deuteron molar mass $N_{\mathrm{A}}m_{\mathrm{d}}$	$M(\mathrm{d}), M_{\mathrm{d}}$	$2.013\,553\,212\,71(35) \times 10^{-3}$	$\mathrm{kg} \cdot \mathrm{mol}^{-1}$	1.7×10^{-10}

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_r
deuteron magnetic moment	μ_d	$0.433\,073\,457(18) \times 10^{-26}$	$J \cdot T^{-1}$	4.2×10^{-8}
to Bohr magneton ratio	μ_d/μ_B	$0.466\,975\,4556(50) \times 10^{-3}$		1.1×10^{-8}
to nuclear magneton ratio	μ_d/μ_N	$0.857\,438\,2284(94)$		1.1×10^{-8}
deuteron-electron magnetic moment ratio	μ_d/μ_e	$-4.664\,345\,537(50) \times 10^{-4}$		1.1×10^{-8}
deuteron-proton magnetic moment ratio	μ_d/μ_p	$0.307\,012\,2083(45)$		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[f]	m_h	$5.006\,411\,74(39) \times 10^{-27}$	kg	7.9×10^{-8}
in u, $m_h = A_r(h)u$ (helion relative atomic mass times u)		$3.014\,932\,234\,69(86)$	u	2.8×10^{-10}
energy equivalent	$m_h c^2$	$4.499\,538\,48(35) \times 10^{-10}$	J	7.9×10^{-8}
in MeV		$2\,808.391\,32(11)$	MeV	4.0×10^{-8}
helion-electron mass ratio	m_h/m_e	$5\,495.885\,238(12)$		2.1×10^{-9}
helion-proton mass ratio	m_h/m_p	$2.993\,152\,658\,50(93)$		3.1×10^{-10}
helion molar mass $N_A m_h$	$M(h), M_h$	$3.014\,932\,234\,69(86) \times 10^{-3}$	$kg \cdot mol^{-1}$	2.8×10^{-10}
shielded helion magnetic moment (gas, sphere, 25 ℃)	μ'_h	$-1.074\,552\,967(45) \times 10^{-26}$	$J \cdot T^{-1}$	4.2×10^{-8}
to Bohr magneton ratio	μ'_h/μ_B	$-1.158\,671\,474(14) \times 10^{-3}$		1.2×10^{-8}
to nuclear magneton ratio	μ'_h/μ_N	$-2.127\,497\,718(25)$		1.2×10^{-8}
shielded helion to proton magnetic moment ratio (gas, sphere, 25 ℃)	μ'_h/μ_p	$-0.761\,766\,563(12)$		1.5×10^{-8}
shielded helion to shielded proton magnetic moment ratio (gas/H_2O, spheres, 25 ℃)	μ'_h/μ'_p	$-0.761\,786\,1313(33)$		4.3×10^{-9}
shielded helion gyromagnetic ratio $2\lvert\mu'_h\rvert/\hbar$	γ'_h	$2.037\,894\,764(85) \times 10^{8}$	$s^{-1} \cdot T^{-1}$	4.2×10^{-8}
	$\gamma'_h/2\pi$	$32.434\,1025(14)$	$MHz \cdot T^{-1}$	4.2×10^{-8}
Alpha particle, α				
alpha particle mass	m_α	$6.644\,655\,98(52) \times 10^{-27}$	kg	7.9×10^{-8}
in u, $m_\alpha = A_r(\alpha)u$ (alpha particle relative atomic mass times u)		$4.001\,506\,1747(10)$	u	2.5×10^{-10}

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

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_r
energy equivalent	$m_\alpha c^2$	$5.971\,918\,97(47) \times 10^{-10}$	J	7.9×10^{-8}
in MeV		$3\,727.379\,04(15)$	MeV	4.0×10^{-8}
alpha particle-electron mass ratio	m_α/m_e	$7\,294.299\,508(16)$		2.1×10^{-9}
alpha particle-proton mass ratio	m_α/m_p	$3.972\,599\,6846(11)$		2.8×10^{-10}
alpha particle molar mass $N_\mathrm{A} m_\alpha$	$M(\alpha), M_\alpha$	$4.001\,506\,1747(10) \times 10^{-3}$	$\mathrm{kg} \cdot \mathrm{mol}^{-1}$	2.5×10^{-10}

Physico-Chemical

Avogadro constant	N_A, L	$6.022\,141\,99(47) \times 10^{23}$	mol^{-1}	7.9×10^{-8}
atomic mass constant $m_\mathrm{u} = \frac{1}{12} m(^{12}\mathrm{C}) = 1\mathrm{u} = 10^{-3}\ \mathrm{kg} \cdot \mathrm{mol}^{-1}/N_\mathrm{A}$	m_u	$1.660\,538\,73(13) \times 10^{-27}$	kg	7.9×10^{-8}
energy equivalent	$m_\mathrm{u} c^2$	$1.492\,417\,78(12) \times 10^{-10}$	J	7.9×10^{-8}
in MeV		$931.494\,013(37)$	MeV	4.0×10^{-8}
Faraday constant[g] $N_\mathrm{A} e$	F	$96\,485.3415(39)$	$\mathrm{C} \cdot \mathrm{mol}^{-1}$	4.0×10^{-8}
molar Planck constant	$N_\mathrm{A} h$	$3.990\,312\,689(30) \times 10^{-10}$	$\mathrm{J} \cdot \mathrm{s} \cdot \mathrm{mol}^{-1}$	7.6×10^{-9}
	$N_\mathrm{A} hc$	$0.119\,626\,564\,92(91)$	$\mathrm{J} \cdot \mathrm{m} \cdot \mathrm{mol}^{-1}$	7.6×10^{-9}
molar gas constant	R	$8.314\,472(15)$	$\mathrm{J} \cdot \mathrm{mol}^{-1} \cdot \mathrm{K}^{-1}$	1.7×10^{-6}
Boltzmann constant R/N_A	k	$1.380\,6503(24) \times 10^{-23}$	$\mathrm{J} \cdot \mathrm{K}^{-1}$	1.7×10^{-6}
in $\mathrm{eV} \cdot \mathrm{K}^{-1}$		$8.617\,342(15) \times 10^{-5}$	$\mathrm{eV} \cdot \mathrm{K}^{-1}$	1.7×10^{-6}
	k/h	$2.083\,6644(36) \times 10^{10}$	$\mathrm{Hz} \cdot \mathrm{K}^{-1}$	1.7×10^{-6}
	k/hc	$69.503\,56(12)$	$\mathrm{m}^{-1} \cdot \mathrm{K}^{-1}$	1.7×10^{-6}
molar volume of ideal gas RT/p				
$T = 273.15\ \mathrm{K}, p = 101.325\ \mathrm{kPa}$	V_m	$22.413\,996(39) \times 10^{-3}$	$\mathrm{m}^3 \cdot \mathrm{mol}^{-1}$	1.7×10^{-6}
Loschmidt constant $N_\mathrm{A}/V_\mathrm{m}$	n_0	$2.686\,7775(47) \times 10^{25}$	m^{-3}	1.7×10^{-6}
$T = 273.15\ \mathrm{K}, p = 100\ \mathrm{kPa}$	V_m	$22.710\,981(40) \times 10^{-3}$	$\mathrm{m}^3 \cdot \mathrm{mol}^{-1}$	1.7×10^{-6}
Sackur-Tetrode constant (absolute entropy constant)[h] $\frac{5}{2} + \ln[(2\pi m_\mathrm{u} k T_1/h^2)^{3/2} k T_1/p_0]$				
$T_1 = 1\ \mathrm{K}, p_0 = 100\ \mathrm{kPa}$	S_0/R	$-1.151\,7048(44)$		3.8×10^{-6}
$T_1 = 1\ \mathrm{K}, p_0 = 101.325\ \mathrm{kPa}$		$-1.164\,8678(44)$		3.7×10^{-6}
Stefan-Boltzmann constant $(\pi^2/60) k^4/\hbar^3 c^2$	σ	$5.670\,400(40) \times 10^{-8}$	$\mathrm{W} \cdot \mathrm{m}^{-2} \cdot \mathrm{K}^{-4}$	7.0×10^{-6}
first radiation constant $2\pi hc^2$	c_1	$3.741\,771\,07(29) \times 10^{-16}$	$\mathrm{W} \cdot \mathrm{m}^2$	7.8×10^{-8}

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[g] The numerical value of F to be used in coulometric chemical measurements is $96\,485.3432(76)$ [7.9×10^{-8}] 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 $K_{\text{J-90}}$ and $R_{\text{K-90}}$ given in the “Adopted Values” table.

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

Quantity	Symbol	Value	Unit	Relative std. uncert. μ_r
first radiation constant for spectral radiance $2hc^2$	c_1L	$1.191\,042\,722(93) \times 10^{-16}$	$\mathrm{W \cdot m^2 \cdot sr^{-1}}$	7.8×10^{-8}
second radiation constant hc/k	c_2	$1.438\,7752(25) \times 10^{-2}$	$\mathrm{m \cdot K}$	1.7×10^{-6}
Wien displacement law constant $b = \lambda_\mathrm{max} T = c_2/4.965\,114\,231\ldots$	b	$2.897\,7686(51) \times 10^{-3}$	$\mathrm{m \cdot K}$	1.7×10^{-6}

Adopted Values

molar mass of ^{12}C	$M(^{12}\mathrm{C})$	12×10^{-3}	$\mathrm{kg \cdot mol^{-1}}$	(exact)
molar mass constant[i] $M(^{12}\mathrm{C})/12$	M_u	1×10^{-3}	$\mathrm{kg \cdot mol^{-1}}$	(exact)
conventional value of Josephson constant[j]	$K_\mathrm{J\text{-}90}$	$483\,597.9$	$\mathrm{GHz \cdot V^{-1}}$	(exact)
conventional value of von Klitzing constant[k]	$R_\mathrm{K\text{-}90}$	$25\,812.807$	Ω	(exact)
standard atmosphere	p_0	$101\,325$	Pa	(exact)
standard acceleration of gravity	g_n	$9.806\,65$	$\mathrm{m \cdot s^{-2}}$	(exact)

X-ray Values

Cu x unit: $\lambda(\mathrm{CuK}\alpha_1)/1\,537.400$	$\mathrm{xu(CuK}\alpha_1)$	$1.002\,077\,03(28) \times 10^{-13}$	m	2.8×10^{-7}
Mo x unit: $\lambda(\mathrm{MoK}\alpha_1)/707.831$	$\mathrm{xu(MoK}\alpha_1)$	$1.002\,099\,59(53) \times 10^{-13}$	m	5.3×10^{-7}
ångstrom star: $\lambda(\mathrm{WK}\alpha_1)/0.209\,0100$	Å*	$1.000\,015\,01(90) \times 10^{-10}$	m	9.0×10^{-7}
lattice parameter[l] of silicon (in vacuum, 22.5 ℃)	a	$543.102\,088(16) \times 10^{-12}$	m	2.9×10^{-8}
$\{220\}$ lattice spacing of silicon $a/\sqrt{8}$ (in vacuum, 22.5 ℃)	d_{220}	$192.015\,5845(56) \times 10^{-12}$	m	2.9×10^{-8}
molar volume of silicon $M(\mathrm{Si})/\rho(\mathrm{Si}) = N_\mathrm{A} a^3/8$ (in vacuum, 22.5 ℃)	$V_\mathrm{m}(\mathrm{Si})$	$12.058\,8369(14) \times 10^{-6}$	$\mathrm{m^3 mol^{-1}}$	1.2×10^{-7}

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[i] The relative atomic mass $A_\mathrm{r}(\mathrm{X})$ of particle X with mass $m(\mathrm{X})$ is defined by $A_\mathrm{r}(\mathrm{X}) = m(\mathrm{X})/m_\mathrm{u}$, where $m_\mathrm{u} = m(^{12}\mathrm{C})/12 = M_\mathrm{u}/N_\mathrm{A} = 1$ u is the atomic mass constant, N_A is the Avogadro constant, and u is the atomic mass unit. Thus the mass of particle X in u is $m(\mathrm{X}) = A_\mathrm{r}(\mathrm{X})\mathrm{u}$ and the molar mass of X is $M(\mathrm{X}) = A_\mathrm{r}(\mathrm{X}) M_\mathrm{u}$.

[j] This is the value adopted internationally for realizing representations of the volt using the Josephson effect.

[k] This is the value adopted internationally for realizing representations of the ohm using the quantum Hall effect.

[l] This is the lattice parameter (unit cell edge length) of an ideal single crystal of naturally occurring Si free of impurities and imperfections, and is deduced from lattice spacing measurements on extremely pure and nearly perfect single crystals of Si by correcting for the effects of impurities.