

# Fundamental Physical Constants — Complete Listing

Quantity	Symbol	Value	Unit	Relative std. uncert. $u_r$
UNIVERSAL				
speed of light in vacuum	$c, c_0$	299 792 458	$\text{m s}^{-1}$	(exact)
magnetic constant	$\mu_0$	$4\pi \times 10^{-7}$ $= 12.566\,370\,614\dots \times 10^{-7}$	$\text{N A}^{-2}$ $\text{N A}^{-2}$	(exact)
electric constant $1/\mu_0 c^2$	$\epsilon_0$	$8.854\,187\,817\dots \times 10^{-12}$	$\text{F m}^{-1}$	(exact)
characteristic impedance of vacuum $\sqrt{\mu_0/\epsilon_0} = \mu_0 c$	$Z_0$	376.730 313 461...	$\Omega$	(exact)
Newtonian constant of gravitation	$G$	$6.673(10) \times 10^{-11}$	$\text{m}^3 \text{kg}^{-1} \text{s}^{-2}$	$1.5 \times 10^{-3}$
	$G/\hbar c$	$6.707(10) \times 10^{-39}$	$(\text{GeV}/c^2)^{-2}$	$1.5 \times 10^{-3}$
Planck constant	$h$	$6.626\,068\,76(52) \times 10^{-34}$	$\text{J s}$	$7.8 \times 10^{-8}$
in eV s		$4.135\,667\,27(16) \times 10^{-15}$	$\text{eV s}$	$3.9 \times 10^{-8}$
$\hbar/2\pi$	$\hbar$	$1.054\,571\,596(82) \times 10^{-34}$	$\text{J s}$	$7.8 \times 10^{-8}$
in eV s		$6.582\,118\,89(26) \times 10^{-16}$	$\text{eV s}$	$3.9 \times 10^{-8}$
Planck mass $(\hbar c/G)^{1/2}$	$m_{\text{P}}$	$2.1767(16) \times 10^{-8}$	$\text{kg}$	$7.5 \times 10^{-4}$
Planck length $\hbar/m_{\text{P}}c = (\hbar G/c^3)^{1/2}$	$l_{\text{P}}$	$1.6160(12) \times 10^{-35}$	$\text{m}$	$7.5 \times 10^{-4}$
Planck time $l_{\text{P}}/c = (\hbar G/c^5)^{1/2}$	$t_{\text{P}}$	$5.3906(40) \times 10^{-44}$	$\text{s}$	$7.5 \times 10^{-4}$
ELECTROMAGNETIC				
elementary charge	$e$	$1.602\,176\,462(63) \times 10^{-19}$	$\text{C}$	$3.9 \times 10^{-8}$
	$e/h$	$2.417\,989\,491(95) \times 10^{14}$	$\text{A J}^{-1}$	$3.9 \times 10^{-8}$
magnetic flux quantum $h/2e$	$\Phi_0$	$2.067\,833\,636(81) \times 10^{-15}$	$\text{Wb}$	$3.9 \times 10^{-8}$
conductance quantum $2e^2/h$	$G_0$	$7.748\,091\,696(28) \times 10^{-5}$	$\text{S}$	$3.7 \times 10^{-9}$
inverse of conductance quantum	$G_0^{-1}$	12 906.403 786(47)	$\Omega$	$3.7 \times 10^{-9}$
Josephson constant <sup>a</sup> $2e/h$	$K_{\text{J}}$	$483\,597.898(19) \times 10^9$	$\text{Hz V}^{-1}$	$3.9 \times 10^{-8}$
von Klitzing constant <sup>b</sup> $h/e^2 = \mu_0 c/2\alpha$	$R_{\text{K}}$	25 812.807 572(95)	$\Omega$	$3.7 \times 10^{-9}$
Bohr magneton $e\hbar/2m_e$	$\mu_{\text{B}}$	$927.400\,899(37) \times 10^{-26}$	$\text{J T}^{-1}$	$4.0 \times 10^{-8}$
in eV T <sup>-1</sup>		$5.788\,381\,749(43) \times 10^{-5}$	$\text{eV T}^{-1}$	$7.3 \times 10^{-9}$
	$\mu_{\text{B}}/h$	$13.996\,246\,24(56) \times 10^9$	$\text{Hz T}^{-1}$	$4.0 \times 10^{-8}$
	$\mu_{\text{B}}/\hbar c$	46.686 4521(19)	$\text{m}^{-1} \text{T}^{-1}$	$4.0 \times 10^{-8}$
	$\mu_{\text{B}}/k$	0.671 7131(12)	$\text{K T}^{-1}$	$1.7 \times 10^{-6}$
nuclear magneton $e\hbar/2m_{\text{p}}$	$\mu_{\text{N}}$	$5.050\,783\,17(20) \times 10^{-27}$	$\text{J T}^{-1}$	$4.0 \times 10^{-8}$
in eV T <sup>-1</sup>		$3.152\,451\,238(24) \times 10^{-8}$	$\text{eV T}^{-1}$	$7.6 \times 10^{-9}$
	$\mu_{\text{N}}/h$	7.622 593 96(31)	$\text{MHz T}^{-1}$	$4.0 \times 10^{-8}$
	$\mu_{\text{N}}/\hbar c$	$2.542\,623\,66(10) \times 10^{-2}$	$\text{m}^{-1} \text{T}^{-1}$	$4.0 \times 10^{-8}$
	$\mu_{\text{N}}/k$	$3.658\,2638(64) \times 10^{-4}$	$\text{K T}^{-1}$	$1.7 \times 10^{-6}$
ATOMIC AND NUCLEAR				
General				
fine-structure constant $e^2/4\pi\epsilon_0\hbar c$	$\alpha$	$7.297\,352\,533(27) \times 10^{-3}$		$3.7 \times 10^{-9}$
inverse fine-structure constant	$\alpha^{-1}$	137.035 999 76(50)		$3.7 \times 10^{-9}$

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Rydberg constant $\alpha^2 m_e c / 2h$	$R_\infty$	10 973 731.568 549(83)	$\text{m}^{-1}$	$7.6 \times 10^{-12}$
	$R_\infty c$	$3.289 841 960 368(25) \times 10^{15}$	Hz	$7.6 \times 10^{-12}$
	$R_\infty hc$	$2.179 871 90(17) \times 10^{-18}$	J	$7.8 \times 10^{-8}$
$R_\infty hc$ in eV		13.605 691 72(53)	eV	$3.9 \times 10^{-8}$
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	$3.7 \times 10^{-9}$
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	$7.8 \times 10^{-8}$
in eV		27.211 3834(11)	eV	$3.9 \times 10^{-8}$
quantum of circulation	$h/2m_e$	$3.636 947 516(27) \times 10^{-4}$	$\text{m}^2 \text{s}^{-1}$	$7.3 \times 10^{-9}$
	$h/m_e$	$7.273 895 032(53) \times 10^{-4}$	$\text{m}^2 \text{s}^{-1}$	$7.3 \times 10^{-9}$
Electroweak				
Fermi coupling constant <sup>c</sup>	$G_F/(\hbar c)^3$	$1.166 39(1) \times 10^{-5}$	$\text{GeV}^{-2}$	$8.6 \times 10^{-6}$
weak mixing angle <sup>d</sup> $\theta_W$ (on-shell scheme)				
$\sin^2 \theta_W = s_W^2 \equiv 1 - (m_W/m_Z)^2$	$\sin^2 \theta_W$	0.2224(19)		$8.7 \times 10^{-3}$
Electron, $e^-$				
electron mass	$m_e$	$9.109 381 88(72) \times 10^{-31}$	kg	$7.9 \times 10^{-8}$
in u, $m_e = A_r(e)$ u (electron relative atomic mass times u)		$5.485 799 110(12) \times 10^{-4}$	u	$2.1 \times 10^{-9}$
energy equivalent	$m_e c^2$	$8.187 104 14(64) \times 10^{-14}$	J	$7.9 \times 10^{-8}$
in MeV		0.510 998 902(21)	MeV	$4.0 \times 10^{-8}$
electron-muon mass ratio	$m_e/m_\mu$	$4.836 332 10(15) \times 10^{-3}$		$3.0 \times 10^{-8}$
electron-tau mass ratio	$m_e/m_\tau$	$2.875 55(47) \times 10^{-4}$		$1.6 \times 10^{-4}$
electron-proton mass ratio	$m_e/m_p$	$5.446 170 232(12) \times 10^{-4}$		$2.1 \times 10^{-9}$
electron-neutron mass ratio	$m_e/m_n$	$5.438 673 462(12) \times 10^{-4}$		$2.2 \times 10^{-9}$
electron-deuteron mass ratio	$m_e/m_d$	$2.724 437 1170(58) \times 10^{-4}$		$2.1 \times 10^{-9}$
electron to alpha particle mass ratio	$m_e/m_\alpha$	$1.370 933 5611(29) \times 10^{-4}$		$2.1 \times 10^{-9}$
electron charge to mass quotient	$-e/m_e$	$-1.758 820 174(71) \times 10^{11}$	$\text{C kg}^{-1}$	$4.0 \times 10^{-8}$
electron molar mass $N_A m_e$	$M(e), M_e$	$5.485 799 110(12) \times 10^{-7}$	$\text{kg mol}^{-1}$	$2.1 \times 10^{-9}$
Compton wavelength $h/m_e c$	$\lambda_C$	$2.426 310 215(18) \times 10^{-12}$	m	$7.3 \times 10^{-9}$
$\lambda_C/2\pi = \alpha a_0 = \alpha^2/4\pi R_\infty$	$\tilde{\lambda}_C$	$386.159 2642(28) \times 10^{-15}$	m	$7.3 \times 10^{-9}$
classical electron radius $\alpha^2 a_0$	$r_e$	$2.817 940 285(31) \times 10^{-15}$	m	$1.1 \times 10^{-8}$
Thomson cross section $(8\pi/3)r_e^2$	$\sigma_e$	$0.665 245 854(15) \times 10^{-28}$	$\text{m}^2$	$2.2 \times 10^{-8}$
electron magnetic moment	$\mu_e$	$-928.476 362(37) \times 10^{-26}$	$\text{J T}^{-1}$	$4.0 \times 10^{-8}$
to Bohr magneton ratio	$\mu_e/\mu_B$	$-1.001 159 652 1869(41)$		$4.1 \times 10^{-12}$
to nuclear magneton ratio	$\mu_e/\mu_N$	$-1 838.281 9660(39)$		$2.1 \times 10^{-9}$
electron magnetic moment anomaly $ \mu_e/\mu_B - 1$	$a_e$	$1.159 652 1869(41) \times 10^{-3}$		$3.5 \times 10^{-9}$
electron $g$ -factor $-2(1 + a_e)$	$g_e$	$-2.002 319 304 3737(82)$		$4.1 \times 10^{-12}$
electron-muon magnetic moment ratio	$\mu_e/\mu_\mu$	206.766 9720(63)		$3.0 \times 10^{-8}$

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electron-proton magnetic moment ratio	$\mu_e/\mu_p$	− 658.210 6875(66)		$1.0 \times 10^{-8}$
electron to shielded proton magnetic moment ratio (H <sub>2</sub> O, sphere, 25 °C)	$\mu_e/\mu'_p$	− 658.227 5954(71)		$1.1 \times 10^{-8}$
electron-neutron magnetic moment ratio	$\mu_e/\mu_n$	960.920 50(23)		$2.4 \times 10^{-7}$
electron-deuteron magnetic moment ratio	$\mu_e/\mu_d$	−2 143.923 498(23)		$1.1 \times 10^{-8}$
electron to shielded helion <sup>e</sup> magnetic moment ratio (gas, sphere, 25 °C)	$\mu_e/\mu'_h$	864.058 255(10)		$1.2 \times 10^{-8}$
electron gyromagnetic ratio $2 \mu_e /\hbar$	$\gamma_e$	$1.760 859 794(71) \times 10^{11}$	$s^{-1} T^{-1}$	$4.0 \times 10^{-8}$
	$\gamma_e/2\pi$	28 024.9540(11)	MHz T <sup>−1</sup>	$4.0 \times 10^{-8}$
Muon, $\mu^-$				
muon mass	$m_\mu$	$1.883 531 09(16) \times 10^{-28}$	kg	$8.4 \times 10^{-8}$
in u, $m_\mu = A_r(\mu) u$ (muon relative atomic mass times u)		0.113 428 9168(34)	u	$3.0 \times 10^{-8}$
energy equivalent in MeV	$m_\mu c^2$	$1.692 833 32(14) \times 10^{-11}$ 105.658 3568(52)	J MeV	$8.4 \times 10^{-8}$ $4.9 \times 10^{-8}$
muon-electron mass ratio	$m_\mu/m_e$	206.768 2657(63)		$3.0 \times 10^{-8}$
muon-tau mass ratio	$m_\mu/m_\tau$	$5.945 72(97) \times 10^{-2}$		$1.6 \times 10^{-4}$
muon-proton mass ratio	$m_\mu/m_p$	0.112 609 5173(34)		$3.0 \times 10^{-8}$
muon-neutron mass ratio	$m_\mu/m_n$	0.112 454 5079(34)		$3.0 \times 10^{-8}$
muon molar mass $N_A m_\mu$	$M(\mu), M_\mu$	$0.113 428 9168(34) \times 10^{-3}$	kg mol <sup>−1</sup>	$3.0 \times 10^{-8}$
muon Compton wavelength $h/m_\mu c$	$\lambda_{C,\mu}$	$11.734 441 97(35) \times 10^{-15}$	m	$2.9 \times 10^{-8}$
$\lambda_{C,\mu}/2\pi$	$\tilde{\lambda}_{C,\mu}$	$1.867 594 444(55) \times 10^{-15}$	m	$2.9 \times 10^{-8}$
muon magnetic moment	$\mu_\mu$	$-4.490 448 13(22) \times 10^{-26}$	J T <sup>−1</sup>	$4.9 \times 10^{-8}$
to Bohr magneton ratio	$\mu_\mu/\mu_B$	$-4.841 970 85(15) \times 10^{-3}$		$3.0 \times 10^{-8}$
to nuclear magneton ratio	$\mu_\mu/\mu_N$	−8.890 597 70(27)		$3.0 \times 10^{-8}$
muon magnetic moment anomaly $ \mu_\mu /(e\hbar/2m_\mu) - 1$	$a_\mu$	$1.165 916 02(64) \times 10^{-3}$		$5.5 \times 10^{-7}$
muon $g$ -factor $-2(1 + a_\mu)$	$g_\mu$	−2.002 331 8320(13)		$6.4 \times 10^{-10}$
muon-proton magnetic moment ratio	$\mu_\mu/\mu_p$	−3.183 345 39(10)		$3.2 \times 10^{-8}$
Tau, $\tau^-$				
tau mass <sup>f</sup>	$m_\tau$	$3.167 88(52) \times 10^{-27}$	kg	$1.6 \times 10^{-4}$
in u, $m_\tau = A_r(\tau) u$ (tau relative atomic mass times u)		1.907 74(31)	u	$1.6 \times 10^{-4}$
energy equivalent in MeV	$m_\tau c^2$	$2.847 15(46) \times 10^{-10}$ 1 777.05(29)	J MeV	$1.6 \times 10^{-4}$ $1.6 \times 10^{-4}$

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tau-electron mass ratio	$m_\tau/m_e$	3 477.60(57)		$1.6 \times 10^{-4}$
tau-muon mass ratio	$m_\tau/m_\mu$	16.8188(27)		$1.6 \times 10^{-4}$
tau-proton mass ratio	$m_\tau/m_p$	1.893 96(31)		$1.6 \times 10^{-4}$
tau-neutron mass ratio	$m_\tau/m_n$	1.891 35(31)		$1.6 \times 10^{-4}$
tau molar mass $N_A m_\tau$	$M(\tau), M_\tau$	$1.907 74(31) \times 10^{-3}$	kg mol <sup>-1</sup>	$1.6 \times 10^{-4}$
tau Compton wavelength $h/m_\tau c$	$\lambda_{C,\tau}$	$0.697 70(11) \times 10^{-15}$	m	$1.6 \times 10^{-4}$
$\lambda_{C,\tau}/2\pi$	$\tilde{\lambda}_{C,\tau}$	$0.111 042(18) \times 10^{-15}$	m	$1.6 \times 10^{-4}$
Proton, p				
proton mass	$m_p$	$1.672 621 58(13) \times 10^{-27}$	kg	$7.9 \times 10^{-8}$
in u, $m_p = A_r(p)$ u (proton relative atomic mass times u)		1.007 276 466 88(13)	u	$1.3 \times 10^{-10}$
energy equivalent	$m_p c^2$	$1.503 277 31(12) \times 10^{-10}$	J	$7.9 \times 10^{-8}$
in MeV		938.271 998(38)	MeV	$4.0 \times 10^{-8}$
proton-electron mass ratio	$m_p/m_e$	1 836.152 6675(39)		$2.1 \times 10^{-9}$
proton-muon mass ratio	$m_p/m_\mu$	8.880 244 08(27)		$3.0 \times 10^{-8}$
proton-tau mass ratio	$m_p/m_\tau$	0.527 994(86)		$1.6 \times 10^{-4}$
proton-neutron mass ratio	$m_p/m_n$	0.998 623 478 55(58)		$5.8 \times 10^{-10}$
proton charge to mass quotient	$e/m_p$	$9.578 834 08(38) \times 10^7$	C kg <sup>-1</sup>	$4.0 \times 10^{-8}$
proton molar mass $N_A m_p$	$M(p), M_p$	$1.007 276 466 88(13) \times 10^{-3}$	kg mol <sup>-1</sup>	$1.3 \times 10^{-10}$
proton Compton wavelength $h/m_p c$	$\lambda_{C,p}$	$1.321 409 847(10) \times 10^{-15}$	m	$7.6 \times 10^{-9}$
$\lambda_{C,p}/2\pi$	$\tilde{\lambda}_{C,p}$	$0.210 308 9089(16) \times 10^{-15}$	m	$7.6 \times 10^{-9}$
proton magnetic moment	$\mu_p$	$1.410 606 633(58) \times 10^{-26}$	J T <sup>-1</sup>	$4.1 \times 10^{-8}$
to Bohr magneton ratio	$\mu_p/\mu_B$	$1.521 032 203(15) \times 10^{-3}$		$1.0 \times 10^{-8}$
to nuclear magneton ratio	$\mu_p/\mu_N$	2.792 847 337(29)		$1.0 \times 10^{-8}$
proton $g$ -factor $2\mu_p/\mu_N$	$g_p$	5.585 694 675(57)		$1.0 \times 10^{-8}$
proton-neutron magnetic moment ratio	$\mu_p/\mu_n$	-1.459 898 05(34)		$2.4 \times 10^{-7}$
shielded proton magnetic moment (H <sub>2</sub> O, sphere, 25 °C)	$\mu'_p$	$1.410 570 399(59) \times 10^{-26}$	J T <sup>-1</sup>	$4.2 \times 10^{-8}$
to Bohr magneton ratio	$\mu'_p/\mu_B$	$1.520 993 132(16) \times 10^{-3}$		$1.1 \times 10^{-8}$
to nuclear magneton ratio	$\mu'_p/\mu_N$	2.792 775 597(31)		$1.1 \times 10^{-8}$
proton magnetic shielding correction 1 - $\mu'_p/\mu_p$ (H <sub>2</sub> O, sphere, 25 °C)	$\sigma'_p$	$25.687(15) \times 10^{-6}$		$5.7 \times 10^{-4}$
proton gyromagnetic ratio $2\mu_p/\hbar$	$\gamma_p$	$2.675 222 12(11) \times 10^8$	s <sup>-1</sup> T <sup>-1</sup>	$4.1 \times 10^{-8}$
	$\gamma_p/2\pi$	42.577 4825(18)	MHz T <sup>-1</sup>	$4.1 \times 10^{-8}$
shielded proton gyromagnetic ratio $2\mu'_p/\hbar$ (H <sub>2</sub> O, sphere, 25 °C)	$\gamma'_p$	$2.675 153 41(11) \times 10^8$	s <sup>-1</sup> T <sup>-1</sup>	$4.2 \times 10^{-8}$
	$\gamma'_p/2\pi$	42.576 3888(18)	MHz T <sup>-1</sup>	$4.2 \times 10^{-8}$
Neutron, n				

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neutron mass	$m_n$	$1.674\,927\,16(13) \times 10^{-27}$	kg	$7.9 \times 10^{-8}$
in u, $m_n = A_r(n)$ u (neutron relative atomic mass times u)		1.008 664 915 78(55)	u	$5.4 \times 10^{-10}$
energy equivalent	$m_n c^2$	$1.505\,349\,46(12) \times 10^{-10}$	J	$7.9 \times 10^{-8}$
in MeV		939.565 330(38)	MeV	$4.0 \times 10^{-8}$
neutron-electron mass ratio	$m_n/m_e$	1 838.683 6550(40)		$2.2 \times 10^{-9}$
neutron-muon mass ratio	$m_n/m_\mu$	8.892 484 78(27)		$3.0 \times 10^{-8}$
neutron-tau mass ratio	$m_n/m_\tau$	0.528 722(86)		$1.6 \times 10^{-4}$
neutron-proton mass ratio	$m_n/m_p$	1.001 378 418 87(58)		$5.8 \times 10^{-10}$
neutron molar mass $N_A m_n$	$M(n), M_n$	$1.008\,664\,915\,78(55) \times 10^{-3}$	kg mol <sup>-1</sup>	$5.4 \times 10^{-10}$
neutron Compton wavelength $h/m_n c$	$\lambda_{C,n}$	$1.319\,590\,898(10) \times 10^{-15}$	m	$7.6 \times 10^{-9}$
$\lambda_{C,n}/2\pi$	$\tilde{\lambda}_{C,n}$	$0.210\,019\,4142(16) \times 10^{-15}$	m	$7.6 \times 10^{-9}$
neutron magnetic moment	$\mu_n$	$-0.966\,236\,40(23) \times 10^{-26}$	J T <sup>-1</sup>	$2.4 \times 10^{-7}$
to Bohr magneton ratio	$\mu_n/\mu_B$	$-1.041\,875\,63(25) \times 10^{-3}$		$2.4 \times 10^{-7}$
to nuclear magneton ratio	$\mu_n/\mu_N$	-1.913 042 72(45)		$2.4 \times 10^{-7}$
neutron $g$ -factor $2\mu_n/\mu_N$	$g_n$	-3.826 085 45(90)		$2.4 \times 10^{-7}$
neutron-electron magnetic moment ratio	$\mu_n/\mu_e$	$1.040\,668\,82(25) \times 10^{-3}$		$2.4 \times 10^{-7}$
neutron-proton magnetic moment ratio	$\mu_n/\mu_p$	-0.684 979 34(16)		$2.4 \times 10^{-7}$
neutron to shielded proton magnetic moment ratio (H <sub>2</sub> O, sphere, 25 °C)	$\mu_n/\mu'_p$	-0.684 996 94(16)		$2.4 \times 10^{-7}$
neutron gyromagnetic ratio $2 \mu_n /\hbar$	$\gamma_n$	$1.832\,471\,88(44) \times 10^8$	s <sup>-1</sup> T <sup>-1</sup>	$2.4 \times 10^{-7}$
	$\gamma_n/2\pi$	29.164 6958(70)	MHz T <sup>-1</sup>	$2.4 \times 10^{-7}$
Deuteron, d				
deuteron mass	$m_d$	$3.343\,583\,09(26) \times 10^{-27}$	kg	$7.9 \times 10^{-8}$
in u, $m_d = A_r(d)$ u (deuteron relative atomic mass times u)		2.013 553 212 71(35)	u	$1.7 \times 10^{-10}$
energy equivalent	$m_d c^2$	$3.005\,062\,62(24) \times 10^{-10}$	J	$7.9 \times 10^{-8}$
in MeV		1 875.612 762(75)	MeV	$4.0 \times 10^{-8}$
deuteron-electron mass ratio	$m_d/m_e$	3 670.482 9550(78)		$2.1 \times 10^{-9}$
deuteron-proton mass ratio	$m_d/m_p$	1.999 007 500 83(41)		$2.0 \times 10^{-10}$
deuteron molar mass $N_A m_d$	$M(d), M_d$	$2.013\,553\,212\,71(35) \times 10^{-3}$	kg mol <sup>-1</sup>	$1.7 \times 10^{-10}$
deuteron magnetic moment	$\mu_d$	$0.433\,073\,457(18) \times 10^{-26}$	J T <sup>-1</sup>	$4.2 \times 10^{-8}$
to Bohr magneton ratio	$\mu_d/\mu_B$	$0.466\,975\,4556(50) \times 10^{-3}$		$1.1 \times 10^{-8}$
to nuclear magneton ratio	$\mu_d/\mu_N$	0.857 438 2284(94)		$1.1 \times 10^{-8}$
deuteron-electron magnetic moment ratio	$\mu_d/\mu_e$	$-4.664\,345\,537(50) \times 10^{-4}$		$1.1 \times 10^{-8}$
deuteron-proton magnetic moment ratio	$\mu_d/\mu_p$	0.307 012 2083(45)		$1.5 \times 10^{-8}$

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deuteron-neutron magnetic moment ratio	$\mu_d/\mu_n$	-0.448 206 52(11)		$2.4 \times 10^{-7}$
Helion, h				
helion mass <sup>e</sup> in u, $m_h = A_r(\text{h})$ u (helion relative atomic mass times u)	$m_h$	$5.006\,411\,74(39) \times 10^{-27}$	kg	$7.9 \times 10^{-8}$
energy equivalent in MeV	$m_h c^2$	3.014 932 234 69(86)	u	$2.8 \times 10^{-10}$
		$4.499\,538\,48(35) \times 10^{-10}$	J	$7.9 \times 10^{-8}$
		2 808.391 32(11)	MeV	$4.0 \times 10^{-8}$
helion-electron mass ratio	$m_h/m_e$	5 495.885 238(12)		$2.1 \times 10^{-9}$
helion-proton mass ratio	$m_h/m_p$	2.993 152 658 50(93)		$3.1 \times 10^{-10}$
helion molar mass $N_A m_h$	$M(\text{h}), M_h$	$3.014\,932\,234\,69(86) \times 10^{-3}$	kg mol <sup>-1</sup>	$2.8 \times 10^{-10}$
shielded helion magnetic moment (gas, sphere, 25 °C)	$\mu'_h$	$-1.074\,552\,967(45) \times 10^{-26}$	J T <sup>-1</sup>	$4.2 \times 10^{-8}$
to Bohr magneton ratio	$\mu'_h/\mu_B$	$-1.158\,671\,474(14) \times 10^{-3}$		$1.2 \times 10^{-8}$
to nuclear magneton ratio	$\mu'_h/\mu_N$	-2.127 497 718(25)		$1.2 \times 10^{-8}$
shielded helion to proton magnetic moment ratio (gas, sphere, 25 °C)	$\mu'_h/\mu_p$	-0.761 766 563(12)		$1.5 \times 10^{-8}$
shielded helion to shielded proton magnetic moment ratio (gas/H <sub>2</sub> O, spheres, 25 °C)	$\mu'_h/\mu'_p$	-0.761 786 1313(33)		$4.3 \times 10^{-9}$
shielded helion gyromagnetic ratio $2 \mu'_h /\hbar$ (gas, sphere, 25 °C)	$\gamma'_h$	$2.037\,894\,764(85) \times 10^8$	s <sup>-1</sup> T <sup>-1</sup>	$4.2 \times 10^{-8}$
	$\gamma'_h/2\pi$	32.434 1025(14)	MHz T <sup>-1</sup>	$4.2 \times 10^{-8}$
Alpha particle, $\alpha$				
alpha particle mass in u, $m_\alpha = A_r(\alpha)$ u (alpha particle relative atomic mass times u)	$m_\alpha$	$6.644\,655\,98(52) \times 10^{-27}$	kg	$7.9 \times 10^{-8}$
energy equivalent in MeV	$m_\alpha c^2$	4.001 506 1747(10)	u	$2.5 \times 10^{-10}$
		$5.971\,918\,97(47) \times 10^{-10}$	J	$7.9 \times 10^{-8}$
		3 727.379 04(15)	MeV	$4.0 \times 10^{-8}$
alpha particle to electron mass ratio	$m_\alpha/m_e$	7 294.299 508(16)		$2.1 \times 10^{-9}$
alpha particle to proton mass ratio	$m_\alpha/m_p$	3.972 599 6846(11)		$2.8 \times 10^{-10}$
alpha particle molar mass $N_A m_\alpha$	$M(\alpha), M_\alpha$	$4.001\,506\,1747(10) \times 10^{-3}$	kg mol <sup>-1</sup>	$2.5 \times 10^{-10}$
PHYSICO-CHEMICAL				
Avogadro constant	$N_A, L$	$6.022\,141\,99(47) \times 10^{23}$	mol <sup>-1</sup>	$7.9 \times 10^{-8}$
atomic mass constant $m_u = \frac{1}{12}m(^{12}\text{C}) = 1$ u $= 10^{-3}$ kg mol <sup>-1</sup> / $N_A$	$m_u$	$1.660\,538\,73(13) \times 10^{-27}$	kg	$7.9 \times 10^{-8}$
energy equivalent in MeV	$m_u c^2$	$1.492\,417\,78(12) \times 10^{-10}$	J	$7.9 \times 10^{-8}$
		931.494 013(37)	MeV	$4.0 \times 10^{-8}$
Faraday constant <sup>g</sup> $N_A e$	$F$	96 485.3415(39)	C mol <sup>-1</sup>	$4.0 \times 10^{-8}$

## Fundamental Physical Constants — Complete Listing

Quantity	Symbol	Value	Unit	Relative std. uncert. $u_r$	
molar Planck constant	$N_A h$	$3.990\,312\,689(30) \times 10^{-10}$	$\text{J s mol}^{-1}$	$7.6 \times 10^{-9}$	
	$N_A h c$	$0.119\,626\,564\,92(91)$	$\text{J m mol}^{-1}$	$7.6 \times 10^{-9}$	
molar gas constant	$R$	$8.314\,472(15)$	$\text{J mol}^{-1} \text{K}^{-1}$	$1.7 \times 10^{-6}$	
Boltzmann constant $R/N_A$ in $\text{eV K}^{-1}$	$k$	$1.380\,6503(24) \times 10^{-23}$	$\text{J K}^{-1}$	$1.7 \times 10^{-6}$	
		$8.617\,342(15) \times 10^{-5}$	$\text{eV K}^{-1}$	$1.7 \times 10^{-6}$	
	$k/h$	$2.083\,6644(36) \times 10^{10}$	$\text{Hz K}^{-1}$	$1.7 \times 10^{-6}$	
	$k/hc$	$69.503\,56(12)$	$\text{m}^{-1} \text{K}^{-1}$	$1.7 \times 10^{-6}$	
molar volume of ideal gas $RT/p$ $T = 273.15 \text{ K}$ , $p = 101.325 \text{ kPa}$	$V_m$	$22.413\,996(39) \times 10^{-3}$	$\text{m}^3 \text{mol}^{-1}$	$1.7 \times 10^{-6}$	
	Loschmidt constant $N_A/V_m$	$n_0$	$2.686\,7775(47) \times 10^{25}$	$\text{m}^{-3}$	$1.7 \times 10^{-6}$
	$T = 273.15 \text{ K}$ , $p = 100 \text{ kPa}$	$V_m$	$22.710\,981(40) \times 10^{-3}$	$\text{m}^3 \text{mol}^{-1}$	$1.7 \times 10^{-6}$
Sackur-Tetrode constant (absolute entropy constant) <sup>h</sup> $\frac{5}{2} + \ln[(2\pi m_u k T_1 / h^2)^{3/2} k T_1 / p_0]$ $T_1 = 1 \text{ K}$ , $p_0 = 100 \text{ kPa}$	$S_0/R$	$-1.151\,7048(44)$		$3.8 \times 10^{-6}$	
		$-1.164\,8678(44)$		$3.7 \times 10^{-6}$	
	$T_1 = 1 \text{ K}$ , $p_0 = 101.325 \text{ kPa}$				
Stefan-Boltzmann constant $(\pi^2/60)k^4/\hbar^3c^2$	$\sigma$	$5.670\,400(40) \times 10^{-8}$	$\text{W m}^{-2} \text{K}^{-4}$	$7.0 \times 10^{-6}$	
	first radiation constant $2\pi hc^2$	$c_1$	$3.741\,771\,07(29) \times 10^{-16}$	$\text{W m}^2$	$7.8 \times 10^{-8}$
	first radiation constant for spectral radiance $2hc^2$	$c_{1L}$	$1.191\,042\,722(93) \times 10^{-16}$	$\text{W m}^2 \text{sr}^{-1}$	$7.8 \times 10^{-8}$
	second radiation constant $hc/k$	$c_2$	$1.438\,7752(25) \times 10^{-2}$	$\text{m K}$	$1.7 \times 10^{-6}$
	Wien displacement law constant $b = \lambda_{\text{max}} T = c_2/4.965\,114\,231\dots$	$b$	$2.897\,7686(51) \times 10^{-3}$	$\text{m K}$	$1.7 \times 10^{-6}$

<sup>a</sup> See the “Adopted values” table for the conventional value adopted internationally for realizing representations of the volt using the Josephson effect.

<sup>b</sup> See the “Adopted values” table for the conventional value adopted internationally for realizing representations of the ohm using the quantum Hall effect.

<sup>c</sup> Value recommended by the Particle Data Group, Caso et al., Eur. Phys. J. C **3**(1-4), 1-794 (1998).

<sup>d</sup> Based on the ratio of the masses of the W and Z bosons  $m_W/m_Z$  recommended by the Particle Data Group (Caso et al., 1998). 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  $\sin^2\hat{\theta}_W(M_Z) = 0.231\,24(24)$ .

<sup>e</sup> The helion, symbol h, is the nucleus of the  $^3\text{He}$  atom.

<sup>f</sup> This and all other values involving  $m_\tau$  are based on the value of  $m_\tau c^2$  in MeV recommended by the Particle Data Group, Caso et al., Eur. Phys. J. C **3**(1-4), 1-794 (1998), but with a standard uncertainty of 0.29 MeV rather than the quoted uncertainty of  $-0.26 \text{ MeV}$ ,  $+0.29 \text{ MeV}$ .

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

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