

RECOMMENDED CONSISTENT VALUES OF THE FUNDAMENTAL PHYSICAL CONSTANTS

The numbers in parentheses are the standard deviation uncertainties in the last digits of the quoted value, computed on the basis of internal consistency.

Quantity	Symbol	Value	Uncertainty, ppm
1. Permeability of Vacuum	μ_0	$4\pi \times 10^{-7} \text{ H m}^{-1}$ $= 12.5663706144 \times 10^{-7} \text{ H m}^{-1}$	
2. Speed of Light in Vacuum	c	$2.99792458(1.2) \times 10^8 \text{ m s}^{-1}$	0.004
3. Permittivity of Vacuum	$\epsilon_0 = (\mu_0 c^2)^{-1}$	$8.85418782(7) \times 10^{-12} \text{ F m}^{-1}$	0.008
4. Fine Structure Constant, $\mu_0 c e^2 / 2h$	α	0.0072973506(60)	0.82
	α^{-1}	137.03604(11)	0.82
5. Elementary Charge	e	$1.6021892(46) \times 10^{-19} \text{ C}$	2.9
6. Planck Constant	h	$6.626176(36) \times 10^{-34} \text{ J Hz}^{-1}$	5.4
	$\hbar = h/2\pi$	$1.0545887(57) \times 10^{-34} \text{ J s}$	5.4
7. Avogadro Constant	N_A	$6.022045(31) \times 10^{23} \text{ mol}^{-1}$	5.1
8. Atomic Mass Unit	$1u = (10^{-3} \text{ kg mol}^{-1})/N_A$	$1.6605655(86) \times 10^{-27} \text{ kg}$	5.1
9. Electron Rest Mass	m_e	$0.9109534(47) \times 10^{-30} \text{ kg}$ $5.4858026(21) \times 10^{-4} \text{ u}$	5.1 0.38
10. Muon Rest Mass	m_μ	$1.883566(11) \times 10^{-28} \text{ kg}$ $0.11342920(26) \text{ u}$	5.6 2.3
11. Proton Rest Mass	m_p	$1.6726485(86) \times 10^{-27} \text{ kg}$ $1.007276470(11) \text{ u}$	5.1 0.011
12. Neutron Rest Mass	m_n	$1.6749543(86) \times 10^{-27} \text{ kg}$ $1.008665012(37) \text{ u}$	5.1 0.037
13. Ratio, Proton Mass to Electron Mass	m_p/m_e	1,836.15152(70)	0.38
14. Ratio, Muon Mass to Electron Mass	m_μ/m_e	206.76865(47)	2.3
15. Specific Electron Charge	e/m_e	$1.7588047(49) \times 10^{11} \text{ C kg}^{-1}$	2.8
16. Faraday Constant	$\mathcal{F} = N_A e$	$9.648456(27) \times 10^4 \text{ C mol}^{-1}$	2.8
17. Magnetic Flux Quantum	$\Phi_0 = h/2e$	$2.0678506(54) \times 10^{-15} \text{ Wb}$ $4.135701(11) \times 10^{-15} \text{ J Hz}^{-1} \text{ C}^{-1}$	2.6 2.6
18. Josephson Frequency-Voltage Ratio	h/e	$483.5939(13) \text{ THz V}^{-1}$	2.6
19. Quantum of Circulation	$h/2m_e$	$3.6369455(60) \times 10^{-4} \text{ J Hz}^{-1} \text{ kg}^{-1}$	1.6
	h/m_e	$7.273891(12) \times 10^{-4} \text{ J Hz}^{-1} \text{ kg}^{-1}$	1.6
20. Rydberg Constant	R_∞	$1.097373177(83) \times 10^7 \text{ m}^{-1}$	0.075
21. Bohr Radius	$a_0 = \alpha/4\pi R_\infty$	$0.52917706(44) \times 10^{-10} \text{ m}$	0.82
22. Electron Compton Wavelength	$\lambda_C = \alpha^2/2R_\infty$	$2.4263089(40) \times 10^{-12} \text{ m}$ $\lambda_C = \lambda_C/2\pi = \alpha a_0$	1.6 1.6
23. Classical Electron Radius	$r_e = \mu_0 e^2/4\pi m_e = \alpha \lambda_C$	$2.8179380(70) \times 10^{-15} \text{ m}$	2.5
24. Electron g -Factor	$1/2 g_e = \mu_e/\mu_B$	1.0011596567(35)	0.0035
25. Muon g -Factor	$1/2 g_\mu$	1.00116616(31)	0.31
26. Proton Moment in Nuclear Magnetons	μ_p/μ_N	2.7928456(11)	0.38
27. Bohr Magnetron	$\mu_B = eh/2m_e$	$9.274078(36) \times 10^{-24} \text{ J T}^{-1}$	3.9
28. Nuclear Magnetron	$\mu_N = eh/2m_p$	$5.050824(20) \times 10^{-27} \text{ J T}^{-1}$	3.9
29. Electron Magnetic Moment	μ_e	$9.284832(36) \times 10^{-24} \text{ J T}^{-1}$	3.9
30. Proton Magnetic Moment	μ_p	$1.4106171(55) \times 10^{-26} \text{ J T}^{-1}$	3.9
31. Proton Magnetic Moment in Bohr Magnetons	μ_p/μ_B	$1.521032209(16) \times 10^{-3}$	0.011
32. Ratio, Electron to Proton Magnetic Moments	μ_e/μ_p	658.2106880(66)	0.010
33. Ratio, Muon Moment to Proton Moment	μ_μ/μ_p	3.1833402(72)	2.3
34. Muon Magnetic Moment	μ_μ	$4.490474(18) \times 10^{-26} \text{ J T}^{-1}$	3.9
35. Proton Gyromagnetic Ratio	γ_p	$2.6751987(75) \times 10^8 \text{ s}^{-1} \text{ T}^{-1}$	2.8
36. Diamagnetic Shielding Factor, Spherical H ₂ O Sample	$1 + \sigma(\text{H}_2\text{O})$	1.000025637(67)	0.067
37. Proton Gyromagnetic Ratio (uncorrected)	γ_p'	$2.6751301(75) \times 10^8 \text{ s}^{-1} \text{ T}^{-1}$	2.8
	$\gamma_p'/2\pi$	42.57602(12) MHz T ⁻¹	2.8
38. Proton Moment in Nuclear Magnetons (uncorrected)	μ_p/μ_N	2.7927740(11)	0.38
39. Proton Compton Wavelength	$\lambda_{C,p} = h/m_p c$	$1.3214099(22) \times 10^{-15} \text{ m}$	1.7
	$\tilde{\lambda}_{C,p} = \lambda_{C,p}/2\pi$	$2.1030892(36) \times 10^{-16} \text{ m}$	1.7
40. Neutron Compton Wavelength	$\lambda_{C,n} = h/m_n c$	$1.3195909(22) \times 10^{-15} \text{ m}$	1.7
	$\tilde{\lambda}_{C,n} = \lambda_{C,n}/2\pi$	$2.1001941(35) \times 10^{-16} \text{ m}$	1.7
41. Molar Gas Constant	R	$8.31441(26) \text{ J mol}^{-1} \text{ K}^{-1}$	31
42. Molar Volume, Ideal Gas ($T_0 = 273.15 \text{ K}$, $p_0 = 1 \text{ atm}$)	$V_m = RT_0/p_0$	$0.02241383(70) \text{ m}^3 \text{ mol}^{-1}$	31
43. Boltzmann Constant	$k = R/N_A$	$1.380662(44) \times 10^{-23} \text{ J K}^{-1}$	32
44. Stefan-Boltzmann Constant	$\sigma = (\pi^2/60)k^4/h^3 c^2$	$5.67032(71) \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$	125
45. First Radiation Constant	$c_1 = 2\pi\hbar c^2$	$3.741832(20) \times 10^{-16} \text{ W m}^2$	5.4
46. Second Radiation Constant	$c_2 = \hbar c/k$	$0.01438786(45) \text{ m K}$	31
47. Gravitational Constant	G	$6.6720(41) \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$	615

Data from CODATA Bulletin No. 11, ICSU CODATA Central Office, 19 Westendstrasse, 6 Frankfurt/Main, German Federal Republic (copies of this bulletin are available at no cost from this office).

ENERGY CONVERSION FACTORS

Quantity	Value	Unit	Error (ppm)
1 kg	5.609538(24)	10^{29} MeV	4.4
1 amu	931.5016(26)	MeV	2.8
Electron mass	0.5110041(16)	MeV	3.1
Proton mass	938.2592(52)	MeV	5.5
Neutron mass	939.5527(52)	MeV	5.5
1 electron volt	1.6021917(70)	10^{-19} J	4.4
		10^{-12} erg	
	2.4179659(81)	10^{14} Hz	3.3
	8.065465(27)	10^5 m ⁻¹	3.3
		10^3 cm ⁻¹	
	1.160485(49)	10^4 K	42
Energy-wavelength conversion	1.2398541(41)	10^{-6} eV·m	3.3
		10^{-4} eV·cm	
Rydberg constant, R_∞	2.179914(17)	10^{-18} J	7.6
		10^{-11} erg	
	13.605826(45)	eV	3.3
	3.2898423(11)	10^{15} Hz	0.35
	1.578936(67)	10^5 K	43
Bohr magneton, μ_B	5.788381(18)	10^{-5} eV T ⁻¹	3.1
	1.3996108(43)	10^{10} Hz T ⁻¹	3.1
	46.68598(14)	m ⁻¹ T ⁻¹	3.1
		10^{-2} cm ⁻¹ ·T ⁻¹	
	0.671733(29)	K T ⁻¹	43
Nuclear magneton, μ_n	3.152526(21)	10^{-8} eV T ⁻¹	6.8
	7.622700(42)	10^6 Hz T ⁻¹	5.5
	2.542659(14)	10^{-2} m ⁻¹ ·T ⁻¹	5.5
		10^{-4} cm ⁻¹ ·T ⁻¹	
	3.65846(16)	10^{-4} K T ⁻¹	44
Gas constant, R_0	8.20562(35)	10^{-2} m ³ ·atm kmole ⁻¹ ·K ⁻¹	42
Standard volume of ideal gas, V_0	22.4136	m ³ kmole ⁻¹	