

APPENDIX B. PHYSICAL CONSTANTS^{1,2,3}

Quantity	Symbol, equation	Value	Uncert. (ppm)
speed of light in vacuum ⁴	c	$2.997\,924\,58 \times 10^{10}$ cm s ⁻¹	0
Planck constant	h	$6.626\,075\,5(40) \times 10^{-27}$ erg s	0.60
Planck constant, reduced	$\hbar = h/2\pi$	$1.054\,572\,66(63) \times 10^{-27}$ erg s $= 6.582\,122\,0(20) \times 10^{-22}$ MeV s	0.60 0.30
electron charge magnitude	e	$4.803\,206\,8(15) \times 10^{-10}$ esu $= 1.602\,177\,33(49) \times 10^{-19}$ coulomb	0.30 0.30
conversion constant	$\hbar c$	197.327 053(59) MeV fm	0.30
conversion constant	$(\hbar c)^2$	0.389 379 66(23) GeV ² mbarn	0.59
electron mass	m_e	$0.510\,999\,06(15)$ MeV/c ² = $9.109\,389\,7(54) \times 10^{-28}$ g	0.30, 0.59
proton mass	m_p	$938.272\,31(28)$ MeV/c ² = $1.672\,623\,1(10) \times 10^{-24}$ g	0.30, 0.59
neutron mass	m_n	$939.565\,63(28)$ MeV/c ² = $1.674\,928\,6(10) \times 10^{-24}$ g $= 1.008\,664\,904(14)$ amu	0.30, 0.59 0.014
deuteron mass	m_d	$1875.613\,39(57)$ MeV/c ²	0.30
atomic mass unit (amu)	(mass C ¹² atom)/12 = (1 g)/N _A	$931.494\,32(28)$ MeV/c ² = $1.660\,540\,2(10) \times 10^{-24}$ g	0.30, 0.59
electron charge to mass ratio	e/m_e	$5.272\,808\,6(16) \times 10^{17}$ esu g ⁻¹ $= 1.758\,819\,62(53) \times 10^8$ coulomb g ⁻¹	0.30 0.30
quantum of magnetic flux	h/e	$4.135\,669\,2(12) \times 10^{-15}$ joule s coulomb ⁻¹	0.30
Josephson frequency-voltage ratio	2e/h	$4.835\,976\,7(14) \times 10^{14}$ cycles s ⁻¹ v ⁻¹	0.30
Faraday constant	F	$9.648\,530\,9(29) \times 10^4$ coulomb mol ⁻¹	0.30
fine-structure constant	$\alpha = e^2/\hbar c$	1/137.035 989 5(61)	0.045
classical electron radius	$r_e = e^2/m_e c^2$	2.817 940 92(38) fm	0.13
electron Compton wavelength	$\lambda_e = \hbar/m_e c = r_e \alpha^{-1}$	$3.861\,593\,23(35) \times 10^{-11}$ cm	0.089
proton Compton wavelength	$\lambda_p = \hbar/m_p c$	$2.103\,089\,37(19) \times 10^{-14}$ cm	0.089
neutron Compton wavelength	$\lambda_n = \hbar/m_n c$	$2.100\,194\,45(19) \times 10^{-14}$ cm	0.089
Bohr radius ($m_{\text{nucleus}} = \infty$)	$\alpha_{\infty} = \hbar^2/m_e e^2 = r_e \alpha^{-2}$	$0.529\,177\,249(24) \times 10^{-8}$ cm	0.045
Rydberg energy	$hcR_{\infty} = m_e e^4/2\hbar^2 = m_e c^2 \alpha^2/2$	13.605 698 1(40) eV	0.30
Thomson cross section	$\sigma_T = 8\pi r_e^2/3$	0.665 246 16(18) barn	0.27
Bohr magneton	$\mu_B = e\hbar/2m_e c$	$5.788\,382\,63(52) \times 10^{-15}$ MeV gauss ⁻¹	0.089
nuclear magneton	$\mu_N = e\hbar/2m_p c$	$3.152\,451\,66(28) \times 10^{-18}$ MeV gauss ⁻¹	0.089
electron cyclotron frequency/field	$\omega_{cycl}^e/B = e/m_e c$	$1.758\,819\,62(53) \times 10^7$ radian s ⁻¹ gauss ⁻¹	0.30
proton cyclotron frequency/field	$\omega_{cycl}^p/B = e/m_p c$	$9.578\,830\,9(29) \times 10^3$ radian s ⁻¹ gauss ⁻¹	0.30
gravitational constant	G _N	$6.672\,59(85) \times 10^{-8}$ cm ³ g ⁻¹ s ⁻²	128
grav. acceleration, sea level, 45° lat.	g	980.665 cm s ⁻²	0
Fermi coupling constant	G _F /($\hbar c$) ³	$1.166\,39(2) \times 10^{-5}$ GeV ⁻²	20
Avogadro number	N _A	$6.022\,136\,7(36) \times 10^{23}$ mol ⁻¹	0.59
molar gas constant, ideal gas at STP	R	$8.314\,510(70) \times 10^7$ erg mol ⁻¹ K ⁻¹	8.4
Boltzmann constant	k	$1.380\,658(12) \times 10^{-16}$ erg K ⁻¹ $= 8.617\,385(73) \times 10^{-5}$ eV K ⁻¹	8.5 8.4
molar volume, ideal gas at STP	N _A k(273.15 K)/(atmosphere)	$22\,414.10(19)$ cm ³ mol ⁻¹	8.4
Stefan-Boltzmann constant	$\sigma = \pi^2 k^4/60\hbar^3 c^2$	$5.670\,51(19) \times 10^{-5}$ erg s ⁻¹ cm ⁻² K ⁻⁴	34
first radiation constant	2 $\pi\hbar c^2$	$3.741\,774\,9(22) \times 10^{-5}$ erg cm ² s ⁻¹	0.60
second radiation constant	hc/k	1.438 769(12) cm K	8.4

¹E.R. Cohen and B.N. Taylor, *Rev. Mod. Phys.* **59**, 1121 (1987).²B.N. Taylor and E.R. Cohen, *J. Res. Natl. Inst. Stand. Technol.* **95**, 497 (1990).³E.R. Cohen and B.N. Taylor, *Phys. Today*, **46**(8) Part 2, BG9 (1993).⁴Defined at the Conférence Générale des Poids et Mesures, October, 1983.

Physical Constants (continued)

Useful constants and conversion factors	
$\pi = 3.141\ 592\ 653\ 589\ 793\ 238$	1 coulomb = $2.997\ 924\ 58 \times 10^9$ esu
$e = 2.718\ 281\ 828\ 459\ 045\ 235$	1 tesla = 10^4 gauss
$\gamma = 0.577\ 215\ 664\ 901\ 532\ 861$	1 atm. = $1.013\ 25 \times 10^6$ dyne/cm ²
1 in = 2.54 cm	0° C = 273.15 K
1 Å = 10^{-8} cm	1 sidereal year = $3.155\ 814\ 98 \times 10^7$ s
1 fm = 10^{-13} cm	1 tropical year = $3.155\ 692\ 52 \times 10^7$ s
1 barn = 10^{-24} cm ²	1 light year = $9.460\ 528 \times 10^{17}$ cm
1 newton = 10^5 dyne	1 parsec = 3.261 633 light year
1 joule = 10^7 erg	1 astro. unit = $1.495\ 978\ 706\ 6(2) \times 10^{13}$ cm
1 eV = $1.602\ 177\ 33(49) \times 10^{-12}$ erg	1 curie = 3.7×10^{10} disintegration/s
1 eV/c ² = $1.782\ 662\ 70(54) \times 10^{-33}$ g	1 rad = 100 erg/g of tissue
1 cal = 4.184 joule	1 roentgen = 1 esu/0.001293 g of air