Appendix A

Units, Conversions, and Physical Constants

The Mohr and Taylor (1998) recommended values of the fundamental physical constants. The digits in parentheses are the one standard deviation uncertainty in the last digits of the given value. Mohr, P. J. and Taylor, B. N., CODATA Recommended Values for the Fundamental Physical Constants: 1998, *Rev. Mod. Phys.* **72**, 35 (2000). See http://www.codata.org/.

Quantity	Symbol	Value	Unit
speed of light in vacuum	c, c_0	299 792 458	m s^{-1}
permeability of vacuum	μ_0	$4\pi \times 10^{-7}$	N A^{-2}
		$=12.566\,370\,614\ldots \times 10^{-7}$	N A^{-2}
permittivity of vacuum	ε_0	$1/\mu_0 c^2$	
		$=8.854\,187\,817\ldots \times 10^{-12}$	F m^{-1}
Newtonian constant of gravitation	G	$6.673(10) \times 10^{-11}$	m^3 kg^{-1} s^{-2}
Planck constant	h	$6.626\,068\,76(52) \times 10^{-34}$	J s
$h/2\pi$	$\hbar$	$1.054\,571\,596(82) \times 10^{-34}$	J s
elementary charge	e	$1.602\,176\,462(63) \times 10^{-19}$	C
Bohr magneton, $e\hbar/2m_e$	μ_B	$9.274\,008\,99(37) \times 10^{-24}$	J T^{-1}
nuclear magneton, $e\hbar/2m_p$	μ_N	$5.050\,783\,17(20) \times 10^{-27}$	J T^{-1}
proton mass	m_p	$1.672\,621\,58(13) \times 10^{-27}$	kg
		$1.007\,276\,466\,88(13)$	u
proton-electron mass ratio	m_p/m_e	$1\,836.152\,667\,5(39)$	
proton magnetic moment	μ_p	$1.410\,606\,633(58) \times 10^{-26}$	J T^{-1}
proton gyromagnetic ratio, $2m_p/\hbar$	γ_p	$2.675\,222\,12(11) \times 10^8$	s^{-1} T^{-1}
fine-structure constant, $e^2/4\pi\varepsilon_0\hbar c$	α	$7.297\,352\,533(27) \times 10^{-3}$	
Rydberg constant, $m_e c\alpha^2/2h$	R_∞	$10\,973\,731.568\,549(83)$	m^{-1}
in hertz, $R_\infty c$		$3.289\,841\,960\,368(25) \times 10^{15}$	Hz
in joules, $R_\infty hc$		$2.179\,871\,90(17) \times 10^{-18}$	J
in electron volts, $R_\infty hc/\{e\}$		$13.605\,691\,72(53)$	eV
Bohr radius, $\alpha/4\pi R_\infty$	a_0	$0.529\,177\,208\,3(19) \times 10^{-10}$	m
Hartree energy, $2R_\infty hc$	E_h	$4.359\,743\,81(34) \times 10^{-18}$	J
in eV, $E_h/\{e\}$		$27.211\,383\,4(11)$	eV

Quantity	Symbol	Value	Unit
electron mass	m_e	$9.109\,381\,88(72) \times 10^{-31}$	kg
		$5.485\,799\,110(12) \times 10^{-4}$	u
electron magnetic moment[a]	μ_e	$-928.476\,362(37) \times 10^{-26}$	$J\ T^{-1}$
in Bohr magnetons[a]	μ_e/μ_B	$-1.001\,159\,652\,186\,9(41)$	
in nuclear magnetons[a]	μ_e/μ_N	$-1\,838.281\,966\,0(39)$	
electron g-factor[a]	g_e	$-2.002\,319\,304\,373\,7(82)$	
Avogadro constant	N_A	$6.022\,141\,99(47) \times 10^{23}$	mol^{-1}
atomic mass constant			
$1\ m_u = m(^{12}C)/12 = 1\ u$	u	$1.660\,538\,73(13) \times 10^{-27}$	kg
Faraday constant, $N_A e$	F	$96\,485.341\,5(39)$	$C\ mol^{-1}$
molar gas constant	R	$8.314\,472(15)$	$J\ mol^{-1}\ K^{-1}$
Boltzmann constant, R/N_A	k	$1.380\,650\,3(24) \times 10^{-23}$	$J\ K^{-1}$
in electron volts, $k/\{e\}$		$8.617\,342(15) \times 10^{-5}$	$eV\ K^{-1}$
in hertz, k/h		$2.083\,664\,4(36) \times 10^{10}$	$Hz\ K^{-1}$
in wavenumbers, k/hc		$69.503\,56(12)$	$m^{-1}\ K^{-1}$
molar volume (ideal gas), RT/p			
$T = 273.15$ K, $p = 101\,325$ Pa	V_m	$22.413\,996(39) \times 10^{-3}$	$m^3\ mol^{-1}$
$T = 273.15$ K, $p = 100$ kPa	V_m	$22.710\,981(40) \times 10^{-3}$	$m^3\ mol^{-1}$
Stefan–Boltzmann			
constant, $(\pi^2/60)k^4/\hbar^3 c^2$	σ	$5.670\,400(40) \times 10^{-8}$	$W\ m^{-2}\ K^{-4}$
first radiation constant, $2\pi hc^2$	c_1	$3.741\,771\,07(29) \times 10^{-16}$	$W\ m^2$
second radiation constant, hc/k	c_2	$0.014\,387\,752(25)$	m K
Wien displacement law constant,			
$b = \lambda_{max} T = c_2/4.965\,114\,231\ldots$	b	$2.897\,768\,6(51) \times 10^{-3}$	m K
electron volt, $(e/C)\ J = \{e\}\ J$	eV	$1.602\,176\,462(63) \times 10^{-19}$	J
standard atmosphere	atm	101 325	Pa
standard acceleration of gravity	g_n	9.806 65	$m\ s^{-2}$

[a]Mohr and Taylor have used negative values for these quantities as recommended by Brown *et al.*, *Mol. Phys.* **98**, 1597 (2000). The equations in this book follow the traditional definitions and require positive values.

Source: Peter Bernath, "Spectra of Atoms and Molecules" 2nd Edition

Fundamental constants

Quantity	Symbol	Value and units†
Speed of light (*in vacuo*)	c	$2.997\ 924\ 58 \times 10^{8}$ m s^{-1} (exact)
Vacuum permeability	μ_0	$4\pi \times 10^{-7}$ H m^{-1} (exact)
Vacuum permittivity	$\varepsilon_0\ (= \mu_0^{-1}c^{-2})$	$8.854\ 187\ 816 \times 10^{-12}$ F m^{-1} (exact)
Charge on proton	e	$1.602\ 176\ 462(63) \times 10^{-19}$ C
Planck constant	h	$6.626\ 068\ 76(52) \times 10^{-34}$ J s
Molar gas constant	R	$8.314\ 472(15)$ J mol^{-1} K^{-1}
Avogadro constant	N_A, L	$6.022\ 141\ 99(47) \times 10^{23}$ mol^{-1}
Boltzmann constant	$k\ (= RN_A^{-1})$	$1.380\ 650\ 3(24) \times 10^{-23}$ J K^{-1}
Atomic mass unit	u $(= 10^{-3}$ kg mol^{-1} $N_A^{-1})$	$1.660\ 538\ 73(13) \times 10^{-27}$ kg
Rest mass of electron	m_e	$9.109\ 381\ 88(72) \times 10^{-31}$ kg
Rest mass of proton	m_p	$1.672\ 621\ 58(13) \times 10^{-27}$ kg
Rydberg constant	R_∞	$1.097\ 373\ 156\ 854\ 8(83) \times 10^{7}$ m^{-1}
Bohr radius	a_0	$5.291\ 772\ 083(19) \times 10^{-11}$ m
Bohr magneton	$\mu_B\ [= e\hbar(2m_e)^{-1}]$	$9.274\ 008\ 99(37) \times 10^{-24}$ J T^{-1}
Nuclear magneton	μ_N	$5.050\ 783\ 17(20) \times 10^{-27}$ J T^{-1}
Electron magnetic moment	μ_e	$-9.284\ 763\ 62(37) \times 10^{-24}$ J T^{-1}
g-Factor for free electron	$g_e\ (= 2\mu_e\mu_B^{-1})$	$2.002\ 319\ 304\ 373\ 7(82)$

† Values taken from Mohr, P. and Taylor, B.N., J. Phys. Chem. Ref. Data, **28**, 1715 (1999), and Rev. Mod. Phys., **72**, 351 (2000). The uncertainties in the final digits are given in the parentheses.

Useful Conversion Factors

Unit	cm^{-1}	MHz	kJ	eV	kJ mol^{-1}
1 cm^{-1}	1	29 979.25	$1.986\ 45 \times 10^{-26}$	$1.239\ 84 \times 10^{-4}$	$1.196\ 27 \times 10^{-2}$
1 MHz	$3.335\ 64 \times 10^{-5}$	1	$6.626\ 08 \times 10^{-31}$	$4.135\ 67 \times 10^{-9}$	$3.990\ 31 \times 10^{-7}$
1 kJ	$5.034\ 11 \times 10^{25}$	$1.509\ 19 \times 10^{30}$	1	$6.241\ 51 \times 10^{21}$	$6.022\ 14 \times 10^{23}$
1 eV	8065.54	$2.417\ 99 \times 10^{8}$	$1.602\ 18 \times 10^{-22}$	1	96.485
1 kJ mol^{-1}	83.5935	$2.506\ 07 \times 10^{6}$	$1.660\ 54 \times 10^{-24}$	$1.036\ 43 \times 10^{-2}$	1

Source: Hollas "Modern Spectroscopy" 4th Edition