

## 13.1: Appendix C- Fundamental Constants

*Note:* These constants are the values recommended in 2006 by CODATA, based on a least-squares adjustment of data from different measurements. The numbers in parentheses for the values represent the uncertainties of the last two digits.

\* c is the speed of light

Quantity	Symbol	Value
Atomic mass unit	u	1.660 538 782 (83) x 10 <sup>-27</sup> kg 931.494 028 (23) MeV/c <sup>2</sup> *
Avogadro's number	N <sub>A</sub>	6.022 141 79 (30) x 10 <sup>23</sup> particles/mol
Bohr magneton	$\mu_B = \frac{e\hbar}{2m_e}$ (13.1.1)	9.274 009 15 (23) x 10 <sup>-24</sup> J/T
Bohr radius	$a_0 = \frac{\hbar^2}{m_e e^2 k_e}$ (13.1.2)	5.291 772 085 9 (36) x 10 <sup>-11</sup> m
Boltzmann's constant	$k_B = \frac{R}{N_A}$ (13.1.3)	1.380 650 4 (24) x 10 <sup>-23</sup> J/K
Compton wavelength	$\lambda_C = \frac{h}{m_e c}$ (13.1.4)	2.426 310 217 5 (33) x 10 <sup>-12</sup> m
Coulomb constant	$k_e = \frac{1}{4\pi\epsilon_0}$ (13.1.5)	8.987 551 788... x 10 <sup>9</sup> N • m <sup>2</sup> /C <sup>2</sup> (exact)
Deuteron mass	m <sub>d</sub>	9.109 382 15 (45) x 10 <sup>-31</sup> kg 5.485 799 094 3(23) x 10 <sup>-4</sup> u 0.510 998 910 (13) MeV/c <sup>2</sup> *
Electron mass	m <sub>e</sub>	9.109 382 15 (45) x 10 <sup>-31</sup> kg 5.485 799 094 3(23) x 10 <sup>-4</sup> u 0.510 998 910 (13) MeV/c <sup>2</sup> *
Electron volt	eV	1.602 176 487 (40) x 10 <sup>-19</sup> J
Elementary charge	e	1.602 176 487 (40) x 10 <sup>-19</sup> C
Gas constant	R	8.314 472 (15) J/mol • K
Gravitational constant	G	6.674 28 (67) x 10 <sup>-11</sup> N • m <sup>2</sup> /kg <sup>2</sup>
Neutron mass	m <sub>n</sub>	1.674 927 211 (84) x 10 <sup>-27</sup> kg 1.008 664 915 97 (43) u 939.565 346 (23) MeV/c <sup>2</sup> *
Nuclear magneton	$\mu_n = \frac{e\hbar}{2m_p}$ (13.1.6)	5.050 783 24 (13) x 10 <sup>-27</sup> J/T
Permeability of free space	$\mu_0$ (13.1.7)	4 $\pi$ x 10 <sup>-7</sup> T • m/A (exact)
Permittivity of free space	$\epsilon_0 = \frac{1}{\mu_0 c^2}$ (13.1.8)	8.854 187 817... x 10 <sup>-12</sup> C <sup>2</sup> /N • m <sup>2</sup> (exact)

Quantity	Symbol	Value
Planck's constant	$h$	$6.626\,068\,96\,(33) \times 10^{-34} \text{ J} \cdot \text{s}$
Reduced Planck's constant	$\hbar = \frac{h}{2\pi}$ (13.1.9)	$1.054\,571\,628\,(53) \times 10^{-34} \text{ J} \cdot \text{s}$
Proton mass	$m_p$	$1.672\,621\,637\,(83) \times 10^{-27} \text{ kg}$ $1.007\,276\,466\,77\,(10) \text{ u}$ $938.272\,013\,(23) \text{ MeV}/c^2 *$
Rydberg constant	$R_H$	$1.097\,373\,156\,852\,7\,(73) \times 10^7 \text{ m}^{-1}$
Speed of light in vacuum	$c$	$2.997\,924\,58 \times 10^8 \text{ m/s (exact)}$

### Useful combinations of constants for calculations:

- $hc = 12,400 \text{ eV} \cdot \text{\AA} = 1240 \text{ eV} \cdot \text{nm} = 1240 \text{ MeV} \cdot \text{fm}$
- $\hbar c = 1973 \text{ eV} \cdot \text{\AA} = 197.3 \text{ eV} \cdot \text{nm} = 197.3 \text{ MeV} \cdot \text{fm}$
- $k_e e^2 = 14.40 \text{ eV} \cdot \text{\AA} = 1.440 \text{ eV} \cdot \text{nm} = 1.440 \text{ MeV} \cdot \text{fm}$
- $k_B T = 0.02585 \text{ eV}$  at  $T = 300 \text{ K}$

### Contributors and Attributions

- Samuel J. Ling (Truman State University), Jeff Sanny (Loyola Marymount University), and Bill Moebs with many contributing authors. This work is licensed by OpenStax University Physics under a [Creative Commons Attribution License \(by 4.0\)](https://creativecommons.org/licenses/by/4.0/).