# An abbreviated list of the CODATA recommended values of the fundamental constants of physics and chemistry based on the 2018 adjustment

| Quantity | Symbol | Value | Unit | Relative std. uncert. $u_r$ |
|---|---|---|---|---|
| speed of light in vacuum | $c$ | 299 792 458 | m s$^{-1}$ | exact |
| Newtonian constant of gravitation | $G$ | $6.674\,30(15) \times 10^{-11}$ | m$^3$ kg$^{-1}$ s$^{-2}$ | $2.2 \times 10^{-5}$ |
| Planck constant* | $h$ | $6.626\,070\,15 \times 10^{-34}$ | J Hz$^{-1}$ | exact |
| | $\hbar$ | $1.054\,571\,817\ldots \times 10^{-34}$ | J s | exact |
| elementary charge | $e$ | $1.602\,176\,634 \times 10^{-19}$ | C | exact |
| vacuum magnetic permeability $4\pi\alpha\hbar/e^2c$ | $\mu_0$ | $1.256\,637\,062\,12(19) \times 10^{-6}$ | N A$^{-2}$ | $1.5 \times 10^{-10}$ |
| vacuum electric permittivity $1/\mu_0c^2$ | $\epsilon_0$ | $8.854\,187\,8128(13) \times 10^{-12}$ | F m$^{-1}$ | $1.5 \times 10^{-10}$ |
| Josephson constant $2e/h$ | $K_J$ | $483\,597.848\,4\ldots \times 10^9$ | Hz V$^{-1}$ | exact |
| von Klitzing constant $\mu_0c/2\alpha = 2\pi\hbar/e^2$ | $R_K$ | $25\,812.807\,45\ldots$ | Ω | exact |
| magnetic flux quantum $2\pi\hbar/(2e)$ | $\Phi_0$ | $2.067\,833\,848\ldots \times 10^{-15}$ | Wb | exact |
| conductance quantum $2e^2/2\pi\hbar$ | $G_0$ | $7.748\,091\,729\ldots \times 10^{-5}$ | S | exact |
| electron mass | $m_e$ | $9.109\,383\,7015(28) \times 10^{-31}$ | kg | $3.0 \times 10^{-10}$ |
| proton mass | $m_p$ | $1.672\,621\,923\,69(51) \times 10^{-27}$ | kg | $3.1 \times 10^{-10}$ |
| proton-electron mass ratio | $m_p/m_e$ | 1836.152 673 43(11) | | $6.0 \times 10^{-11}$ |
| fine-structure constant $e^2/4\pi\epsilon_0\hbar c$ | $\alpha$ | $7.297\,352\,5693(11) \times 10^{-3}$ | | $1.5 \times 10^{-10}$ |
| inverse fine-structure constant | $\alpha^{-1}$ | 137.035 999 084(21) | | $1.5 \times 10^{-10}$ |
| Rydberg frequency $\alpha^2m_ec^2/2h$ | $cR_\infty$ | $3.289\,841\,960\,2508(64) \times 10^{15}$ | Hz | $1.9 \times 10^{-12}$ |
| Boltzmann constant | $k$ | $1.380\,649 \times 10^{-23}$ | J K$^{-1}$ | exact |
| Avogadro constant | $N_A$ | $6.022\,140\,76 \times 10^{23}$ | mol$^{-1}$ | exact |
| molar gas constant $N_Ak$ | $R$ | $8.314\,462\,618\ldots$ | J mol$^{-1}$ K$^{-1}$ | exact |
| Faraday constant $N_Ae$ | $F$ | $96\,485.332\,12\ldots$ | C mol$^{-1}$ | exact |
| Stefan-Boltzmann constant $(\pi^2/60)k^4/\hbar^3c^2$ | $\sigma$ | $5.670\,374\,419\ldots \times 10^{-8}$ | W m$^{-2}$ K$^{-4}$ | exact |
| Non-SI units accepted for use with the SI | | | | |
| electron volt ($e$/C) J | eV | $1.602\,176\,634 \times 10^{-19}$ | J | exact |
| (unified) atomic mass unit $\frac{1}{12}m(^{12}C)$ | u | $1.660\,539\,066\,60(50) \times 10^{-27}$ | kg | $3.0 \times 10^{-10}$ |

* The energy of a photon with frequency $\nu$ expressed in unit Hz is $E = h\nu$ in J. Unitary time evolution of the state of this photon is given by $\exp(-iEt/\hbar)|\varphi\rangle$, where $|\varphi\rangle$ is the photon state at time $t = 0$ and time is expressed in unit s. The ratio $Et/\hbar$ is a phase.

| | | | | |
|---|---|---|---|---|
| 1 eV | (1 eV) = $1.602\,176\,634 \times 10^{-19}$ J | $(1\text{ eV})/c^2 = 1.782\,661\,921\ldots \times 10^{-36}$ kg | $(1\text{ eV})/hc = 8.065\,543\,937\ldots \times 10^5$ m$^{-1}$ | $(1\text{ eV})/h = 2.417\,989\,242\ldots \times 10^{14}$ Hz |
| 1 eV | $(1\text{ eV})/k = 1.160\,451\,812\ldots \times 10^4$ K | 1 eV = 11604.518 K = 8065.543937 cm$^{-1}$ = 1239.8 nm, 10 eV = 123.98 nm | | |

$$1\text{ eV} = 96.48533212\text{ kJ mol}^{-1}$$

$$\lambda = \frac{c}{\nu},\ h\nu = \frac{hc}{\lambda}$$

$$1\text{ kJ mol}^{-1} = 10.36426966\text{ meV} \Leftrightarrow 120.27\text{ K}$$

$$1\text{ kcal mol}^{-1} = 43.3641\text{ meV} \Leftrightarrow 503.2\text{ K},\quad 1\text{ cal} = 4.184\text{ J}$$

$$300\text{ K} = 25.852\text{ meV} = 2.4943\text{ kJ mol}^{-1}$$

$$\mathrm{ATP}^{4-} + \mathrm{H_2O} \Rightarrow \mathrm{ADP}^{3-} + \mathrm{HPO_4^{2-}} + \mathrm{H^+} : \underbrace{-30.5\text{ kJ mol}^{-1}}_{=\Delta_rG^\oplus} = -316\text{ meV} \Leftrightarrow 3670\text{ K}$$

$$1\text{ F} = 1\text{ C V}^{-1}$$

$$\frac{e^2}{4\pi\epsilon_0 r} = \frac{[\mathrm{C}^2]}{[\mathrm{Fm}^{-1}\mathrm{m}]} = [\mathrm{CV}] = [\mathrm{J}]$$

$$1\text{ D} = c^{-1} \times 10^{-21}\text{ C m} = 3.33564 \times 10^{-30}\text{ C m}$$

$$\frac{\text{Weber}}{\text{m}^2} = \frac{\text{N}}{\text{A m}} = \text{T} = 10^4\text{ Gauss}$$

Dirac constant (exact)

$$\hbar = \frac{h}{2\pi} = 6.582119569 \times 10^{-16}\text{ eV s}$$

1 atom = 760 mmHg = 760 torr
=1013.25 hPa = 1013.25 mbar

| Quantity | Symbol | Value | Unit | Relative std. uncert. $u_r$ |
|---|---|---|---|---|
| | | General | | |
| fine-structure constant $e^2/4\pi\epsilon_0\hbar c$ | $\alpha$ | $7.297\,352\,5693(11) \times 10^{-3}$ | | $1.5 \times 10^{-10}$ |
| inverse fine-structure constant | $\alpha^{-1}$ | $137.035\,999\,084(21)$ | | $1.5 \times 10^{-10}$ |
| Rydberg frequency $\alpha^2 m_e c^2/2h = E_h/2h$ | $cR_\infty$ | $3.289\,841\,960\,2508(64) \times 10^{15}$ | Hz | $1.9 \times 10^{-12}$ |
| energy equivalent | $hc\,R_\infty$ | $2.179\,872\,361\,1035(42) \times 10^{-18}$ | J | $1.9 \times 10^{-12}$ |
| | | $13.605\,693\,122\,994(26)$ | eV | $1.9 \times 10^{-12}$ |
| Rydberg constant | $R_\infty$ | $10\,973\,731.568\,160(21)$ | $[m^{-1}]^*$ | $1.9 \times 10^{-12}$ |
| Bohr radius $\hbar/\alpha m_e c = 4\pi\epsilon_0\hbar^2/m_e e^2$ | $a_0$ | $5.291\,772\,109\,03(80) \times 10^{-11}$ | m | $1.5 \times 10^{-10}$ |
| Hartree energy $\alpha^2 m_e c^2 = e^2/4\pi\epsilon_0 a_0 = 2hcR_\infty$ | $E_h$ | $4.359\,744\,722\,2071(85) \times 10^{-18}$ | J | $1.9 \times 10^{-12}$ |
| | | $27.211\,386\,245\,988(53)$ | eV | $1.9 \times 10^{-12}$ |

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