Name	Symbol	Value	Examples
percent	%	10^{-2}	The isotopic abundance of carbon-13 expressed as a mole fraction is $x = 1.1\%$
part per million	ppm	10^{-6}	The relative uncertainty in the Planck constant $h(= 6.626\,0755(40) \times 10^{-34}$ J s) is 0.60 ppm The mass fration of impurities in a sample of copper was found to be less than 3 ppm, $w < 3$ppm

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These multiples of the unit one are not part of the SI and ISO recommends that these symbols should never be used. They are also frequently used as units of 'concentration' without a clear indication of the type of fraction implied (e.g. mole fraction, mass fraction or volume fraction). To avoid ambiguity they should only be used in a context where the meaning of the quantity is carefully defined. Even then, the use of an appropriate SI unit ratio may be preferred.

Deprecated Usage

Adding extra labels to ppm and similar symbols, such as ppmv (meaning ppm by volume) should be avoided. Qualifying labels may be added to symbols for physical quantities, but never to units.

The symbols % and ppm should not be used in combination with other units. In table headings and in labelling the axes of graphs the use of % and ppm in the denominator is to be avoided. Although one would write $x(^{13}\text{C}) = 1.1\%$, the notation 100 x is to be preferred to $x/\%$ in tables and graphs.

The further symbols listed in the table below are also to be found in the literature, but their use is to be deprecated. Note that the names and symbols for 10^{-9} and 10^{-12} in this table are based on the American system of names. In other parts of the world a billion sometimes stands for 10^{12} and a trillion for 10^{18}. Note also that the symbol ppt is sometimes used for part per thousand, and sometimes for part per trillion.

To avoid ambiguity the symbols ppb, ppt and pphm should not be used.

Name	Symbol	Value	Examples
part per hundred	pph	10^{-2}	(Exactly equivalent to percent, %)
part per thousand	ppt	10^{-3}	Atmospheric carbon dioxide is depleted in carbon-13 mass fraction by 7‰ (or 7 ppt) relative to ocean water
permille[a]	‰	10^{-3}	
part per hundred million	pphm	10^{-8}	The mass fraction of impurity in the metal was less than 5 pphm
part per billion	ppb	10^{-9}	The air quality standard for ozone is a volume fraction of $\phi = 120$ ppb
part per trillion	ppt	10^{-12}	The natural background volume fraction of NO in air was found to be $\phi = 140$ ppt
part per quadrillion	ppq	10^{-15}	

[a]The permille is also spelled per mille, per mill, permil or pro mille.

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9. FUNDAMENTAL PHYSICAL CONSTANTS

The following values were recommended by the CODATA Task Group on Fundamental Constants in 1986. For each constant the standard deviation uncertainty in the least significant digits is given in parentheses.

Quantity	Symbol	Value
Permeability of vacuum[a]	μ_0	$4\pi \times 10^{-7}$ H m^{-1} (defined)
Speed of light in vacuum	c_0	299 792 458 m s^{-1} (defined)
Permitttivity of vacuum[a]	$\varepsilon_0 = 1/\mu_0 c_0^2$	8.854 187 816 … $\times 10^{-12}$ F m^{-1}
Plank constant	h	6.626 075 5 (40) $\times 10^{-34}$ J s
	$\hbar = h/2\pi$	1.054 572 66 (63) $\times 10^{-34}$ J s
Elementary charge	e	1.602 177 33 (49) $\times 10^{-19}$ C
Electron rest mass	m_e	9.109 389 7 (54) $\times 10^{-31}$ kg
Proton rest mass	m_p	1.672 623 1 (10) $\times 10^{-27}$ kg
Neutron rest mass	m_n	1.674 928 6 (10) $\times 10^{-27}$ kg
Atomic mass constant, (unified atomic mass unit)	$m_u = 1$ u	1.660 540 2 (10) $\times 10^{-27}$ kg
Avogadro constant	L, N_A	6.022 136 7 (36) $\times 10^{23}$ mol^{-1}
Boltzmann constant	K	1.380 658 (12) $\times 10^{-23}$ J K^{-1}
Faraday constant	F	9.648 530 9 (29) $\times 10^{4}$ C mol^{-1}
Gas constant	R	8.314 510 (70) J K^{-1} mol^{-1}
Zero of the Celsius scale		273.15 K (defined)
Molar volume, ideal gas, $p = 1$ bar, $\theta = 0°C$		22.711 08 (19) l mol^{-1}
Standard atmosphere	atm	101 325 Pa (defined)
Fine structure constant	$\alpha = \mu_0 e^2 c_0/2h$	7.297 353 08 (33) $\times 10^{-3}$
	α^{-1}	137.035 989 5 (61)
Bohr radius	$a_0 = 4\pi\varepsilon_0\hbar^2/m_e e^2$	5.291 772 49 (24) $\times 10^{-11}$ m
Hartree energy	$E_h = \hbar^2/m_e a_0^2$	4.359 748 2 (26) $\times 10^{-18}$ J
Rydberg constant	$R_\infty = E_h/2hc_0$	1.097 373 153 4 (13) $\times 10^{7}$ m^{-1}
Bohr magneton	$\mu_B = e\hbar/2m_e$	9.2740154 (31) $\times 10^{-24}$ J T^{-1}
Electron magnetic moment	μ_e	9.284 770 1 (31) $\times 10^{-24}$ J T^{-1}
Landé g-factor for free electron	$g_e = 2\mu_e/\mu_B$	2.002 319 304 386 (20)
Nuclear magnetcon	$\mu_N = (m_e/m_p)\mu_B$	5.050 786 6 (17) $\times 10^{-27}$ J T^{-1}
Protron magnetic moment	μ_p	1.410 607 61 (47) $\times 10^{-26}$ J T^{-1}
Proton magnetogyric ratio	γ_p	2.675 221 28 (81) $\times 10^{8}$ s^{-1} T^{-1}
Magnetic moment of protons in H_2O, μ'_p	μ'_p/μ_B	1.520 993 129 (17) $\times 10^{-3}$
Proton resonance frequency per field in H_2O	$\gamma'_p/2\pi$	42.576 375 (13) MHz T^{-1}
Stefan-Boltzmann constant	$\sigma = 2\pi^5 k^4/15h^3 c_0^2$	5.670 51 (19) $\times 10^{-8}$ W m^{-2} K^{-4}
First radiation constant	$c_1 = 2\pi h c_o^2$	3.741 7749 (22) $\times 10^{-16}$ W m^2
Second radiation constant	$c_2 = hc_o/k$	1.438 769 (12) $\times 10^{-2}$ m K
Gravitational constant	G	6.672 59 (85) $\times 10^{-11}$ m^3 kg^{-1}s^{-2}
Standard acceleration of free fall	g_n	9.806 65 m s^{-2} (defined)

[a]H m^{-1} = N A^{-2} = N s^2 C^{-2}; F m^{-1} = C^2 J^{-1} m^{-1}; ε_0 may be calculated exactly from the defined values of μ_0 an c_0.

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Values of Common Mathematical Constants

Mathematical constant	Symbol	Value
Ratio of circumference to diameter of a circle	π	3.141 592 653 59
Base of natural logarithms	e	2.718 281 828 46
Natural logarithm of 10	ln 10	2.302 585 092 99

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