New Values for the

PHYSICAL CONSTANTS

As Recommended by the NAS-NRC

A new, consistent set of values for the physical constants has been recommended by the Committee on Fundamental Constants of the National Academy of Sciences—National Research Council. These values were presented to the Second International Conference on Nuclidic Masses held in Vienna, July 15-19, 1963. At the General Assembly meeting of the International Union of Pure and Applied Physics held in Warsaw, September 18-23, 1963, the following statement was adopted: "The Commission [on Nuclidic Masses and Related Atomic Constants] expects that these values will be widely used and will help to remove many of the confusions that have arisen from the use of differing sets of constants. In addition, it is expected that the appearance of this list will encourage further experimental work aimed at improving our knowledge of these values."

The NAS-NRC Committee consulted a large number of experimental results, and it rejected some of them because of inconsistency with other data and apparent lack of reliability. The Committee remarked that if the rejected data had been included the reported values would have been altered somewhat, but not greatly.

A full report of the calculations and considerations entering into the new set of values was presented by J. W. M. DuMond and E. R. Cohen at the Vienna Conference, and will be published in the conference proceedings. The new values have been reported in the October 1963 issue of the National Bureau of Standards *Technical News Bulletin.**

Table 1 lists defined values and equivalents, and Table 2 contains energy conversion factors. The new values of the constants are given in Table 3. The data retained for least-squares' adjustment were assigned standard deviations, and the estimated error limit is three standard errors. It

* A wallet-size card giving recommended values of selected constants can be obtained, upon request, from the Office of Technical Information, National Bureau of Standards, Washington, D.C., 20234.

Table 1. Defined values and equivalents

Meter	(m)	1 650 763.73 wavelengths in vacuo of the unperturbed transition $2p_{10}-5d_5$ in ^{86}Kr
Kilogram	(kg)	mass of the international kilogram at Sèvres, France
Second	(s)	1/31 556 925.974 7 of the tropical year at 12^h ET, 0 January 1900
Degree Kelvin	(°K)	defined in the thermodynamic scale by assigning 273.16 °K to the triple point of water (freezing point, 273.15 °K = 0 °C)
Unified atomic mass unit	(u)	1/12 the mass of an atom of the ^{12}C nuclide
Mole	(mol)	amount of substance containing same number of atoms as 12g of pure ^{12}C
Standard acceleration of free fall	(g_n)	9.806 65 m s^{-2}, 980.665 cm s^{-2}
Normal atmospheric pressure	(atm)	101 325 N m^{-2}, 1 013 250 dyn cm^{-2}
Thermochemical calorie	(cal_{th})	4.1840 J, 4.1840×10^7 erg
International Steam Table calorie	($cal_{I\,T}$)	4.1868 J, 4.1868×10^7 erg
Liter	(l)	0.001 000 028 m^3, 1 000.028 cm^3 (recommended by CIPM, 1950)
Inch	(in.)	0.0254 m, 2.54 cm
Pound (avdp.)	(lb)	0.453 592 37 kg, 453.592 37 g

Table 2. Energy conversion factors

	Formula	*Factor*	*Error limit*	*Conversion*			
				Système International (MKSA)		*Centimeter-gram-second (CGS)*	
Electron-volt	eV	1.60210	7	$\times10^{-19}$	J$(e$V$)^{-1}$	$\times10^{-12}$	erg $(e$V$)^{-1}$
Energy associated with							
Unified atomic mass unit	c^2/Ne	9.31478	15	10^8	eV u^{-1}	10^8	eV u^{-1}
Proton mass	m_pc^2/e	9.38256	15	10^8	eV m_p^{-1}	10^8	eV m_p^{-1}
Neutron mass	m_nc^2/e	9.39550	15	10^8	eV m_n^{-1}	10^8	eV m_n^{-1}
Electron mass	m_ec^2/e	5.11006	5	10^5	eV m_e^{-1}	10^5	eV m_e^{-1}
Cycle	e/h	2.41804	7	10^{14}	Hz$(e$V$)^{-1}$	10^{14}	$s^{-1}(e$V$)^{-1}$
Wavelength	ch/e	1.23981	4	10^{-6}	eV m	10^{-4}	eV cm
Wave number	e/ch	8.06573	23	10^5	$m^{-1}(e$V$)^{-1}$	10^3	$cm^{-1}(e$V$)^{-1}$
°K	e/k	1.16049	16	10^4	°K$(e$V$)^{-1}$	10^4	°K$(e$V$)^{-1}$

is believed unlikely that the true value of any of the constants differs from the tabular value by as much as the stated uncertainty. The uncertainties in constants computed from fundamental ones may be either greater or less than is obtained by a simple combination of the elemental uncertainties because of the correlation among the elemental constants introduced by the least-squares adjustment. The values are based upon the assumption that the acceleration of gravity is correctly given by adding −0.013 gal (1 gal = 1 cm s^{-2}) to the value of g given in the Potsdam system. The system of atomic masses in which ^{12}C is assigned the value 12, is employed. The symbols used are those recommended by the Commission on Symbols, Units, and Nomenclature (SUN Commission) of IUPAP. (See *Physics Today*, June 1962.)

The members of the NAS-NRC Committee on Fundamental Constants, are J. A. Bearden, E. R. Cohen, J. W. M. DuMond, L. P. McCullough, N. Ramsey, F. D. Rossini, J. S. Thomsen, G. Waddington, and Alvin G. McNish, Chairman.

Table 3. Adjusted values of constants

Constant	Symbol	Value	Est. ‡ error limit	Unit: Système International (MKSA)		Unit: Centimeter-gram-second (CGS)	
Speed of light in vacuum	c	2.997925	3	$\times 10^{8}$	m s^{-1}	$\times 10^{10}$	cm s^{-1}
Elementary charge	e	1.60210	7	10^{-19}	C	10^{-20}	$cm^{1/2}g^{1/2}$ *
		4.80298	20	.....		10^{-10}	$cm^{3/2}g^{1/2}s^{-1}$ †
Avogadro constant	N_A	6.02252	28	10^{23}	mol^{-1}	10^{23}	mol^{-1}
Electron rest mass	m_e	9.1091	4	10^{-31}	kg	10^{-28}	g
		5.48597	9	10^{-4}	u	10^{-4}	u
Proton rest mass	m_p	1.67252	8	10^{-27}	kg	10^{-24}	g
		1.00727663	24	10^{0}	u	10^{0}	u
Neutron rest mass	m_n	1.67482	8	10^{-27}	kg	10^{-24}	g
		1.0086654	13	10^{0}	u	10^{0}	u
Faraday constant	F	9.64870	16	10^{4}	C mol^{-1}	10^{3}	$cm^{1/2}g^{1/2}mol^{-1}$ *
		2.89261	5	.....		10^{14}	$cm^{3/2}g^{1/2}s^{-1}mol^{-1}$ †
Planck constant	h	6.6256	5	10^{-34}	J s	10^{-27}	erg s
	$\hbar$	1.05450	7	10^{-34}	J s	10^{-27}	erg s
Fine structure constant	α	7.29720	10	10^{-3}	.....	10^{-3}	
	$1/\alpha$	1.370388	19	10^{2}	.....	10^{2}	
	$\alpha/2\pi$	1.161385	16	10^{-3}	.....	10^{-3}	
	α^2	5.32492	14	10^{-5}	.....	10^{-5}	
Charge to mass ratio for electron	e/m_e	1.758796	19	10^{11}	C kg^{-1}	10^{7}	$cm^{1/2}g^{-1/2}$ *
		5.27274	6	.....		10^{17}	$cm^{3/2}g^{-1/2}s^{-1}$ †
Quantum-charge ratio	h/e	4.13556	12	10^{-15}	J s C^{-1}	10^{-7}	$cm^{3/2}g^{1/2}s^{-1}$ *
		1.37947	4	.....		10^{-17}	$cm^{1/2}g^{1/2}$ †
Compton wavelength of electron	λ_C	2.42621	6	10^{-12}	m	10^{-10}	cm
	$\lambda_C/2\pi$	3.86144	9	10^{-13}	m	10^{-11}	cm
Compton wavelength of proton	$\lambda_{C,p}$	1.32140	4	10^{-15}	m	10^{-13}	cm
	$\lambda_{C,p}/2$	2.10307	6	10^{-16}	m	10^{-14}	cm
Rydberg constant	R_∞	1.0973731	3	10^{7}	m^{-1}	10^{5}	cm^{-1}
Bohr radius	a_0	5.29167	7	10^{-11}	m	10^{-9}	cm
Electron radius	r_e	2.81777	11	10^{-15}	m	10^{-13}	cm
	r^2_e	7.9398	6	10^{-30}	m^2	10^{-26}	cm^2
Thomson cross section	$8\pi r^2_e/3$	6.6516	5	10^{-29}	m^2	10^{-25}	cm^2
Gyromagnetic ratio of proton	γ	2.67519	2	10^{8}	rad $s^{-1}T^{-1}$	10^{4}	rad $s^{-1}G^{-1}$ *
	$\gamma/2\pi$	4.25770	3	10^{7}	Hz T^{-1}	10^{3}	$s^{-1}G^{-1}$ *
(uncorrected for diamagnetism, H_2O)	γ'	2.67512	2	10^{8}	rad $s^{-1}T^{-1}$	10^{4}	rad $s^{-1}G^{-1}$ *
	$\gamma'/2\pi$	4.25759	3	10^{7}	Hz T^{-1}	10^{3}	$s^{-1}G^{-1}$ *
Bohr magneton	μ_B	9.2732	6	10^{-24}	J T^{-1}	10^{-21}	erg G^{-1} *
Nuclear magneton	μ_N	5.0505	4	10^{-27}	J T^{-1}	10^{-24}	erg G^{-1} *
Proton moment	μ_p	1.41049	13	10^{-26}	J T^{-1}	10^{-23}	erg G^{-1} *
	μ_p/μ_N	2.79276	7	10^{0}	.....	10^{0}	
(uncorrected for diamagnetism, H_2O)	μ'_p/μ_N	2.79268	7	10^{0}	.....	10^{0}	
Anomalous electron moment corrn.	$(\mu_e/\mu_0)-1$	1.159615	15	10^{-3}	.....	10^{-3}	
Zeeman splitting constant	μ_B/hc	4.66858	4	10^{1}	$m^{-1}T^{-1}$	10^{-5}	$cm^{-1}G^{-1}$ *
Gas constant	R	8.3143	12	10^{0}	J $°K^{-1}$ mol^{-1}	10^{7}	erg $°K^{-1}$ mol^{-1}
Normal volume perfect gas	V_0	2.24136	30	10^{-2}	m^3 mol^{-1}	10^{4}	cm^3 mol^{-1}
Boltzmann constant	k	1.38054	18	10^{-23}	J $°K^{-1}$	10^{-16}	erg $°K^{-1}$
First radiation constant $(2\pi hc^2)$	c_1	3.7405	3	10^{-16}	W m^2	10^{-5}	erg cm^2 s^{-1}
Second radiation constant	c_2	1.43879	19	10^{-2}	m °K	10^{0}	cm °K
Wien displacement constant	b	2.8978	4	10^{-3}	m °K	10^{-1}	cm °K
Stefan-Boltzmann constant	σ	5.6697	29	10^{-8}	W m^{-2} $°K^{-4}$	10^{-5}	erg cm^{-2} s^{-1} $°K^{-4}$
Gravitational constant	G	6.670	15	10^{-11}	N m^2 kg^{-2}	10^{-8}	dyn cm^2 g^{-2}

‡Based on 3 standard deviations, applied to last digits in preceding column. *Electromagnetic system. †Electrostatic system.
C—coulomb J—joule Hz—hertz W—watt N—newton T—tesla G—gauss