INTERNATIONAL STANDARD

ISO
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AMENDMENT 1
1998-12-15

Quantities and units —

Part 1: Space and time
Part 2: Periodic and related phenomena
Part 3: Mechanics
Part 4: Heat
Part 5: Electricity and magnetism
Part 6: Light and related electromagnetic radiations
Part 7: Acoustics
Part 8: Physical chemistry and molecular physics
Part 9: Atomic and nuclear physics
Part 10: Nuclear reactions and ionizing radiations
Part 12: Characteristic numbers
Part 13: Solid state physics

AMENDMENT 1

Grandeurs et unités —

Partie 1: Espace et temps
Partie 2: Phénomènes périodiques et connexes
Partie 3: Mécanique
Partie 4: Chaleur
Partie 5: Électricité et magnétisme
Partie 6: Lumière et rayonnements électromagnétiques connexes
Partie 7: Acoustique
Partie 8: Chimie physique et physique moléculaire
Partie 9: Physique atomique et nucléaire
Partie 10: Réactions nucléaires et rayonnements ionisants
Partie 12: Nombres caractéristiques
Partie 13: Physique de l'état solide

AMENDEMENT 1

Reference number
ISO 31 (parts 1 to 10, 12 and 13):1992/Amd.1:1998(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Amendment 1 to parts 1 to 10, 12 and 13 of International Standard ISO 31:1992 was prepared by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors.*

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Quantities and units —

Part 1: Space and time
Part 2: Periodic and related phenomena
Part 3: Mechanics
Part 4: Heat
Part 5: Electricity and magnetism
Part 6: Light and related electromagnetic radiations
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Part 10: Nuclear reactions and ionizing radiations
Part 12: Characteristic numbers
Part 13: Solid state physics

AMENDMENT 1

Page v

Replace subclause 0.3.2 with the following text:

0.3.2 Remark on units for quantities of dimension one

The coherent unit for any quantity of dimension one is the number one, symbol 1. When the value of such a quantity is expressed, the unit symbol **1** is generally not written out explicitly.

EXAMPLE

Refractive index $n = 1{,}53 \times 1 = 1{,}53$

Prefixes shall not be used to form multiples or submultiples of this unit. Instead of prefixes, powers of 10 may be used.

EXAMPLE

Reynolds number $Re = 1{,}32 \times 10^3$

Considering that plane angle is generally expressed as the ratio of two lengths and solid angle as the ratio of two areas, in 1995 the CGPM has specified that, in the International System of Units, the radian, rad, and the steradian, sr, are "dimensionless" derived units. This implies that the quantities plane angle and solid angle are considered as derived quantities of dimension one. The units radian and steradian may be omitted, or they may be used in expressions for derived units to facilitate distinction between quantities of different nature but having the same dimension.

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Price based on 1 page

INTERNATIONAL STANDARD

ISO 31-9

Third edition
1992-09-01

Quantities and units —

Part 9:
Atomic and nuclear physics

Grandeurs et unités —

Partie 9: Physique atomique et nucléaire

Reference number
ISO 31-9:1992(E)

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 31-9 was prepared by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors.*

This third edition cancels and replaces the second edition (ISO 31-9:1980). The major technical changes from the second edition are the following:

— the decision by the International Committee for Weights and Measures (Comité International des Poids et Mesures, CIPM) in 1980 concerning the status of supplementary units has been incorporated;

— one new item has been added;

— a number of new chemical elements have been added in annex A;

— units in use temporarily have been transferred to the "Conversion factors and remarks" column.

The scope of Technical Committee ISO/TC 12 is standardization of units and symbols for quantities and units (and mathematical symbols) used within the different fields of science and technology, giving, where necessary, definitions of these quantities and units. Standard conversion factors for converting between the various units also come under the scope of the TC. In fulfilment of this responsibility, ISO/TC 12 has prepared ISO 31.

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ISO 31 consists of the following parts, under the general title *Quantities and units*:

- *Part 0: General principles*
- *Part 1: Space and time*
- *Part 2: Periodic and related phenomena*
- *Part 3: Mechanics*
- *Part 4: Heat*
- *Part 5: Electricity and magnetism*
- *Part 6: Light and related electromagnetic radiations*
- *Part 7: Acoustics*
- *Part 8: Physical chemistry and molecular physics*
- *Part 9: Atomic and nuclear physics*
- *Part 10: Nuclear reactions and ionizing radiations*
- *Part 11: Mathematical signs and symbols for use in the physical sciences and technology*
- *Part 12: Characteristic numbers*
- *Part 13: Solid state physics*

Annexes A and B form an integral part of this part of ISO 31. Annexes C and D are for information only.

Introduction

0.1 Arrangement of the tables

The tables of quantities and units in ISO 31 are arranged so that the quantities are presented on the left-hand pages and the units on the corresponding right-hand pages.

All units between two full lines belong to the quantities between the corresponding full lines on the left-hand pages.

Where the numbering of an item has been changed in the revision of a part of ISO 31, the number in the preceding edition is shown in parentheses on the left-hand page under the new number for the quantity; a dash is used to indicate that the item in question did not appear in the preceding edition.

0.2 Tables of quantities

The most important quantities within the field of this document are given together with their symbols and, in most cases, definitions. These definitions are given merely for identification; they are not intended to be complete.

The vectorial character of some quantities is pointed out, especially when this is needed for the definitions, but no attempt is made to be complete or consistent.

In most cases only one name and only one symbol for the quantity are given; where two or more names or two or more symbols are given for one quantity and no special distinction is made, they are on an equal footing. When two types of italic (sloping) letter exist (for example as with ϑ, θ; φ, ϕ; g, *g*) only one of these is given. This does not mean that the other is not equally acceptable. In general it is recommended that such variants should not be given different meanings. A symbol within parentheses implies that it is a "reserve symbol", to be used when, in a particular context, the main symbol is in use with a different meaning.

0.3 Tables of units

0.3.1 General

Units for the corresponding quantities are given together with the international symbols and the definitions. For further information, see ISO 31-0.

The units are arranged in the following way:

a) The names of the SI units are given in large print (larger than text size). The SI units have been adopted by the General Conference on Weights and Measures (Conference Générale des Poids et Mesures, CGPM).

The SI units and their decimal multiples and sub-multiples are recommended, although the decimal multiples and sub-multiples are not explicitly mentioned.

b) The names of non-SI units which may be used together with SI units because of their practical importance or because of their use in specialized fields are given in normal print (text size).

These units are separated by a broken line from the SI units for the quantities concerned.

c) The names of non-SI units which may be used temporarily together with SI units are given in small print (smaller than text size) in the "Conversion factors and remarks" column.

d) The names of non-SI units which should not be combined with SI units are given only in annexes in some parts of ISO 31. These annexes are informative and not integral parts of the standard. They are arranged in three groups:

   1) special names of units in the CGS system;

   2) names of units based on the foot, pound and second and some other related units;

   3) names of other units.

0.3.2 Remark on units for quantities of dimension one

The coherent unit for any quantity of dimension one is the number one (1). When the value of such a quantity is expressed, the unit 1 is generally not written out explicitly. Prefixes shall not be used to form multiples or sub-multiples of this unit. Instead of prefixes, powers of 10 may be used.

EXAMPLES

Refractive index $n = 1{,}53 \times 1 = 1{,}53$

Reynolds number $Re = 1{,}32 \times 10^3$

Considering that plane angle is generally expressed as the ratio between two lengths, and solid angle as the ratio between an area and the square of a length, the CIPM specified in 1980 that, in the International System of Units, the radian and steradian are dimensionless derived units. This implies that the quantities plane angle and solid angle are considered as dimensionless derived quantities. The units radian and steradian may be used in expressions for derived units to facilitate distinction between quantities of different nature but having the same dimension.

0.4 Numerical statements

All numbers in the "Definition" column are exact.

When numbers in the "Conversion factors and remarks" column are exact, the word "exactly" is added in parentheses after the number.

0.5 Special remarks

The fundamental physical constants given in this part of ISO 31 are either quoted in or calculated from the consistent values of the fundamental physical constants published in CODATA Bulletin 63 (1986).

The names and symbols of the chemical elements are given in annex A.

The names and symbols for nuclides of the radioactive series are given in annex C.

For some of the "electrical" quantities, equations based on three base quantities, in particular equations of the Gaussian system, are given in annex D, together with the numerical values of certain atomic constants expressed in CGS units of the Gaussian system. For further details, see the introduction to ISO 31-5:1992, subclause 0.5.2.

Quantities and units —

Part 9:
Atomic and nuclear physics

1 Scope

This part of ISO 31 gives names and symbols for quantities and units of atomic and nuclear physics. Where appropriate, conversion factors are also given.

2 Names and symbols

The names and symbols for quantities and units of atomic and nuclear physics are given on the following pages.

ATOMIC AND NUCLEAR PHYSICS

Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-1	proton number, atomic number	Z	Number of protons in an atomic nucleus	A nuclide is a species of atom with specified numbers of protons and neutrons. Nuclides with the same value of Z are called isotopes. The atomic number in the periodic table is equal to the proton number. See also annex B.
9-2	neutron number	N	Number of neutrons in an atomic nucleus	Nuclides with the same value of N are called isotones. $N-Z$ is called the neutron excess number.
9-3	nucleon number, mass number	A	Number of nucleons in an atomic nucleus	$A = Z + N$ Nuclides with the same value of A are called isobars. See also annex B.
9-4.1	mass of atom (of a nuclide X), nuclidic mass	m_a, $m(\mathrm{X})$	Rest mass of a neutral atom in the ground state	For hydrogen $^1\mathrm{H}$, $m(^1\mathrm{H}) = (1{,}673\ 534\ 0 \pm 0{,}000\ 001\ 0) \times 10^{-27}$ kg $= (1{,}007\ 825\ 048 \pm 0{,}000\ 000\ 012)$ u
9-4.2	unified atomic mass constant	m_u	1/12 of the rest mass of a neutral atom of the nuclide $^{12}\mathrm{C}$ in the ground state	$m_u = (1{,}660\ 540\ 2 \pm 0{,}000\ 001\ 0) \times 10^{-27}$ kg [1)] = 1 u. $\frac{m_a}{m_u}$ is called the relative nuclidic mass.

1) CODATA Bulletin 63 (1986).

Units — ATOMIC AND NUCLEAR PHYSICS

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-1.a	one	1		See the introduction, subclause 0.3.2.
9-2.a	one	1		See the introduction, subclause 0.3.2.
9-3.a	one	1		See the introduction, subclause 0.3.2.
9-4.a	kilogram	kg		
9-4.b	unified atomic mass unit	u	1 unified atomic mass unit is equal to 1/12 of the rest mass of a neutral atom of the nuclide ^{12}C in the ground state	1 u = (1,660 540 2 ± 0,000 001 0) × 10^{-27} kg [1)]

1) CODATA Bulletin 63 (1986).

ATOMIC AND NUCLEAR PHYSICS (*continued*) Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-5.1	(rest) mass of electron	m_e		For a particle with rest mass m, the quantity mc^2 is called its rest energy. $m_e = (9{,}109\ 389\ 7 \pm 0{,}000\ 005\ 4) \times 10^{-31}$ kg = $(5{,}485\ 799\ 03 \pm 0{,}000\ 000\ 13) \times 10^{-4}$ u [1]
9-5.2	(rest) mass of proton	m_p		$m_p = (1{,}672\ 623\ 1 \pm 0{,}000\ 001\ 0) \times 10^{-27}$ kg = $(1{,}007\ 276\ 470 \pm 0{,}000\ 000\ 012)$ u [1]
9-5.3	(rest) mass of neutron	m_n		$m_n = (1{,}674\ 928\ 6 \pm 0{,}000\ 001\ 0) \times 10^{-27}$ kg = $(1{,}008\ 664\ 904 \pm 0{,}000\ 000\ 014)$ u [1]

1) CODATA Bulletin 63 (1986).

Item No.	Quantity	Symbol	Definition	Remarks
9-6	elementary charge	e	Electric charge of a proton	The electric charge of an electron is equal to $-e$. $e = (1{,}602\ 177\ 33 \pm 0{,}000\ 000\ 49) \times 10^{-19}$ C [1]

1) CODATA Bulletin 63 (1986).

Item No.	Quantity	Symbol	Definition	Remarks
9-7	Planck constant	h	Elementary quantum of action	$h = (6{,}626\ 075\ 5 \pm 0{,}000\ 004\ 0) \times 10^{-34}$ J · s [1] $\hbar = h/2\pi = (1{,}054\ 572\ 66 \pm 0{,}000\ 000\ 63) \times 10^{-34}$ J · s [1]

1) CODATA Bulletin 63 (1986).

Item No.	Quantity	Symbol	Definition	Remarks
9-8	Bohr radius	a_0	$a_0 = 4\pi\varepsilon_0\hbar^2/m_e e^2$	$a_0 = (5{,}291\ 772\ 49 \pm 0{,}000\ 000\ 24) \times 10^{-11}$ m [1]

1) CODATA Bulletin 63 (1986).

Item No.	Quantity	Symbol	Definition	Remarks
9-9	Rydberg constant	R_∞	$R_\infty = \dfrac{e^2}{8\pi\varepsilon_0 a_0 hc}$	$R_\infty = (1{,}097\ 373\ 153\ 4 \pm 0{,}000\ 000\ 001\ 3) \times 10^7\ \text{m}^{-1}$ [1] For hydrogen ^{1}H, $R_H = R_\infty/(1 + m_e/m_p)$ The quantity $R_\infty \cdot hc$ is called the Rydberg energy (Ry).

1) CODATA Bulletin 63 (1986).

Units — ATOMIC AND NUCLEAR PHYSICS (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-5.a	kilogram	kg		
9-5.b	unified atomic mass unit	u		1 u = (1,660 540 2 ± 0,000 001 0) × 10^{-27} kg [1)]

1) CODATA Bulletin 63 (1986).

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-6.a	coulomb	C		
9-7.a	joule second	J · s		
9-8.a	metre	m		ångström (Å), 1 Å = 10^{-10} m
9-9.a	reciprocal metre, metre to the power minus one	m^{-1}		

ATOMIC AND NUCLEAR PHYSICS (*continued*) Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-10	Hartree energy	E_h	$E_h = e^2/4\pi\varepsilon_0 a_0 = 2R_\infty \cdot hc$	$E_h = (4{,}359\ 748\ 2 \pm 0{,}000\ 002\ 6) \times 10^{-18}$ J [1)]
1) CODATA Bulletin 63 (1986).				
9-11.1	magnetic moment of particle or nucleus	μ	Expectation value of the component of the electromagnetic moment in the direction of the magnetic field in the quantum state with maximum magnetic quantum number	The energy in a magnetic field with magnetic flux density B, in the quantum state with maximum magnetic quantum number, in a vacuum, is equal to $-\mu B$.
9-11.2	Bohr magneton	μ_B	$\mu_B = e\hbar/2m_e$	$\mu_B = (9{,}274\ 015\ 4 \pm 0{,}000\ 003\ 1) \times 10^{-24}$ A · m² [1)]
9-11.3	nuclear magneton	μ_N	$\mu_N = e\hbar/2m_p = (m_e/m_p)\mu_B$	$\mu_N = (5{,}050\ 786\ 6 \pm 0{,}000\ 001\ 7) \times 10^{-27}$ A · m² [1)]
1) CODATA Bulletin 63 (1986).				
9-12	gyromagnetic coefficient, (gyromagnetic ratio)	γ	$\gamma = \mu/J\hbar$ where J is the angular momentum quantum number	The gyromagnetic coefficient of the proton is indicated by γ_p. $\gamma_p = (2{,}675\ 221\ 28 \pm 0{,}000\ 000\ 81) \times 10^8$ A · m²/(J · s) [1)]
1) CODATA Bulletin 63 (1986).				
9-13.1	g-factor of atom or electron	g	$\gamma = -g\frac{\mu_B}{\hbar} = -g\frac{e}{2m_e}$	These quantities are also called g-values. For a free electron, $g_e = 2{,}002\ 319\ 304\ 386 \pm 0{,}000\ 000\ 000\ 020$
9-13.2	g-factor of nucleus or nuclear particle	g	$\gamma = g\frac{\mu_N}{\hbar} = g\frac{e}{2m_p}$	
9-14.1	Larmor angular frequency	ω_L	$\omega_L = \frac{e}{2m_e}B$	$\nu_L = \omega_L/2\pi$ is called the Larmor frequency.
9-14.2	nuclear precession angular frequency	ω_N	$\omega_N = \gamma B$ where B is the magnetic flux density	

Units ATOMIC AND NUCLEAR PHYSICS (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-10.a	joule	J		
9-11.a	ampere square metre	$A \cdot m^2$		
9-12.a	ampere square metre per joule second	$A \cdot m^2/(J \cdot s)$		$1\ A \cdot m^2/(J \cdot s) = 1\ A \cdot s/kg = 1\ T^{-1} \cdot s^{-1}$
9-13.a	one	1		See the introduction, subclause 0.3.2.
9-14.a	radian per second	rad/s		See the introduction, subclause 0.3.2.
9-14.b	reciprocal second, second to the power minus one	s^{-1}		

ATOMIC AND NUCLEAR PHYSICS (*continued*) Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-15	cyclotron angular frequency	ω_c	$\omega_c = \frac{q}{m} B$ where q/m is the charge to mass ratio of the particle and B is the magnetic flux density	$\nu_c = \omega_c/2\pi$ is called the cyclotron frequency.
9-16	nuclear quadrupole moment	Q	Expectation value of the quantity $(1/e) \int \left(3z^2 - r^2\right) \varrho(x, y, z)\, dV$ in the quantum state with the nuclear spin in the field (z) direction; $\varrho(x, y, z)$ is the nuclear charge density, e is the elementary charge and dV is the volume element $dx\, dy\, dz$	The electric nuclear quadrupole moment is eQ.
9-17	nuclear radius	R	Average radius of volume in which the nuclear matter is included	This quantity is not exactly defined. It is given approximately by $R = r_0 A^{1/3}$ where $r_0 \approx 1{,}2 \times 10^{-15}$ m and A is the nucleon number.
9-18	orbital angular momentum quantum number	l_i, L		l_i refers to a particle i; L is used for the whole system.
9-19	spin angular momentum quantum number	s_i, S		s_i refers to a particle i; S is used for the whole system.
9-20	total angular momentum quantum number	j_i, J		j_i refers to a particle i; J is used for the whole system.
9-21	nuclear spin quantum number	I		In nuclear and particle physics, J is often used.
9-22	hyperfine structure quantum number	F		
9-23	principal quantum number	n		

Units ATOMIC AND NUCLEAR PHYSICS (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-15.a	radian per second	rad/s		See the introduction, subclause 0.3.2.
9-15.b	reciprocal second, second to the power minus one	s^{-1}		
9-16.a	metre squared	m^2		
9-17.a	metre	m		Quantity 9-17 is usually expressed in femtometres. 1 fm = 10^{-15} m
9-18.a	one	1		See the introduction, subclause 0.3.2.
9-19.a	one	1		See the introduction, subclause 0.3.2.
9-20.a	one	1		See the introduction, subclause 0.3.2.
9-21.a	one	1		See the introduction, subclause 0.3.2.
9-22.a	one	1		See the introduction, subclause 0.3.2.
9-23.a	one	1		See the introduction, subclause 0.3.2.

ATOMIC AND NUCLEAR PHYSICS (*continued*) Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-24	magnetic quantum number	m_i, M		m_i refers to a particle i; M is used for the whole system. Subscripts L, S, J, etc., as appropriate, may be added to indicate the angular momentum involved.
9-25	fine-structure constant	α	$\alpha = e^2/4\pi\varepsilon_0\hbar c$	$\alpha = (7{,}297\ 353\ 08 \pm 0{,}000\ 000\ 33) \times 10^{-3}$ [1] $1/\alpha = 137{,}035\ 989\ 5 \pm 0{,}000\ 006\ 1$ [1]

1) CODATA Bulletin 63 (1986).

Item No.	Quantity	Symbol	Definition	Remarks
9-26	electron radius	r_e	$r_e = e^2/4\pi\varepsilon_0 m_e c^2$	$r_e = (2{,}817\ 940\ 92 \pm 0{,}000\ 000\ 38) \times 10^{-15}$ m [1]

1) CODATA Bulletin 63 (1986).

Item No.	Quantity	Symbol	Definition	Remarks
9-27	Compton wavelength	λ_C	$\lambda_C = 2\pi\hbar/mc = h/mc$ where m is the rest mass of the particle	For the proton, $\lambda_{C,p} = (1{,}321\ 410\ 02 \pm 0{,}000\ 000\ 12) \times 10^{-15}$ m [1] For the neutron, $\lambda_{C,n} = (1{,}319\ 591\ 10 \pm 0{,}000\ 000\ 12) \times 10^{-15}$ m [1]

1) CODATA Bulletin 63 (1986).

Item No.	Quantity	Symbol	Definition	Remarks
9-28.1	mass excess	Δ	$\Delta = m_a - Am_u$	If the binding energy of the atomic electrons is neglected, Bc^2 is equal to the binding energy of the nucleus.
9-28.2	mass defect	B	$B = Zm(^1\text{H}) + Nm_n - m_a$	
9-29.1	relative mass excess	Δ_r	$\Delta_r = \Delta/m_u$	
9-29.2	relative mass defect	B_r	$B_r = B/m_u$	
9-30.1	packing fraction	f	$f = \Delta_r/A$	
9-30.2	binding fraction	b	$b = B_r/A$	

Units				ATOMIC AND NUCLEAR PHYSICS (*continued*)
Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-24.a	one	1		See the introduction, subclause 0.3.2.
9-25.a	one	1		See the introduction, subclause 0.3.2.
9-26.a	metre	m		
9-27.a	metre	m		
9-28.a	kilogram	kg		
9-28.b	unified atomic mass unit	u		1 u = (1,660 540 2 ± 0,000 001 0) × 10^{-27} kg [1)] Quantities 9-28.1 and 9-28.2 are usually expressed in unified atomic mass units.
9-29.a	one	1		See the introduction, subclause 0.3.2.
9-30.a	one	1		See the introduction, subclause 0.3.2.

1) CODATA Bulletin 63 (1986).

ATOMIC AND NUCLEAR PHYSICS (*continued*) — Quantities

Item No.	Quantity	Symbol	Definition	Remarks
9-31	mean life	τ	$\tau = \int_0^\infty t \frac{dN}{dt}\,dt \Big/ \int_0^\infty \frac{dN}{dt}\,dt$ where $\frac{dN}{dt}\,dt$ is the number of atoms decaying in the time interval dt	For exponential decay, $N = N_0\,e^{-\lambda t}$, and $\tau = 1/\lambda$ is the time required for N to decrease from N_0 to N_0/e.
9-32	level width	Γ	$\Gamma = \frac{\hbar}{\tau}$	
9-33	activity	A	Average number of spontaneous nuclear transitions from a particular energy state occurring in an amount of a radionuclide in a small time interval, divided by that interval	$A = -\,dN/dt$ For exponential decay, $A = \lambda N$, where λ is the decay constant (see 9-36).
9-34	massic activity, specific activity	a	Activity divided by the total mass of the sample	
9-35 (—)	volumic activity, activity concentration	c_A	Activity divided by the total volume of the sample	
9-36 (*9-35.1*)	decay constant, disintegration constant	λ	Probability of decay in a small time interval, divided by that interval. $dN/dt = -\lambda N$ where N is the number of radioactive atoms at time t, and $\lambda = 1/\tau$	This quantity is a constant only for exponential decay. $\lambda = \Sigma\lambda_a$, where λ_a denotes the probability of decay to a specified final state and the sum is over all final states.
9-37 (*9-36.1*)	half-life	$T_{1/2}$	Average time required for the decay of one half of the atoms of a sample of a radioactive nuclide	For exponential decay, $T_{1/2} = (\ln 2)/\lambda = \tau \ln 2$
9-38 (*9-37.1*)	alpha disintegration energy	Q_α	Sum of the kinetic energy of the α particle produced in the disintegration process and the recoil energy of the product atom in the reference frame in which the emitting nucleus is at rest before its disintegration	The ground-state alpha disintegration energy, $Q_{\alpha,0}$, also includes the energy of any gamma radiation produced.

Units — ATOMIC AND NUCLEAR PHYSICS (*continued*)

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-31.a	second	s		
9-32.a	joule	J		
9-32.b	electronvolt	eV		1 eV = (1,602 177 33 ± 0,000 000 49) × 10^{-19} J [1)]

1) CODATA Bulletin 63 (1986).

Item No.	Name of unit	International symbol for unit	Definition	Conversion factors and remarks
9-33.a	becquerel	Bq	1 Bq = 1 s^{-1}	The becquerel is a special name for second to the power minus one, to be used as the SI unit of activity. curie (Ci), 1 Ci = 3,7 × 10^{10} Bq (exactly)
9-34.a	becquerel per kilogram	Bq/kg		
9-35.a	becquerel per cubic metre	Bq/m^3		
9-36.a	reciprocal second, second to the power minus one	s^{-1}		
9-37.a	second	s		
9-38.a	joule	J		
9-38.b	electronvolt	eV		Quantity 9-38 is usually expressed in electronvolts. 1 eV = (1,602 177 33 ± 0,000 000 49) × 10^{-19} J [1)]

1) CODATA Bulletin 63 (1986).

ATOMIC AND NUCLEAR PHYSICS (*concluded*)				Quantities
Item No.	**Quantity**	**Symbol**	**Definition**	**Remarks**
9-39 (*9-38.1*)	maximum beta particle energy	E_β	Maximum energy of the energy spectrum in a beta disintegration process	
9-40 (*9-39.1*)	beta disintegration energy	Q_β	Sum of the maximum beta particle energy E_β and the recoil energy of the atom produced in the reference frame in which the emitting nucleus is at rest before its disintegration	For positron emitters, the energy for the production of an electron pair has to be added to the sum mentioned in the definition. The ground-state beta disintegration energy, $Q_{\beta,0}$, also includes the energy of any gamma radiation produced.
9-41 (*9-40.1*)	internal conversion factor	α	Ratio of the number of internal conversion electrons to the number of gamma quanta emitted by the atom in a given transition	The quantity $\alpha/(\alpha + 1)$ is also used and may be called the internal conversion fraction. Partial conversion factors referring to the various electron shells K, L, ... are indicated by α_K, α_L, ... α_K/α_L is called the K to L internal conversion ratio.

Units				ATOMIC AND NUCLEAR PHYSICS (*concluded*)
Item No.	**Name of unit**	**International symbol for unit**	**Definition**	**Conversion factors and remarks**
9-39.a	joule	J		
9-39.b	electronvolt	eV		Quantity 9-39 is usually expressed in electronvolts. 1 eV = (1,602 177 33 ± 0,000 000 49) × 10^{-19} J [1)]
1) CODATA Bulletin 63 (1986).				
9-40.a	joule	J		
9-40.b	electronvolt	eV		Quantity 9-40 is usually expressed in electronvolts. 1 eV = (1,602 177 33 ± 0,000 000 49) × 10^{-19} J [1)]
1) CODATA Bulletin 63 (1986).				
9-41.a	one	1		See the introduction, subclause 0.3.2.

Annex A
(normative)

Names and symbols of the chemical elements[1]

Atomic number	Name	Symbol
1	hydrogen	H
2	helium	He
3	lithium	Li
4	beryllium	Be
5	boron	B
6	carbon	C
7	nitrogen	N
8	oxygen	O
9	fluorine	F
10	neon	Ne
11	sodium, (natrium)	Na
12	magnesium	Mg
13	aluminium	Al
14	silicon	Si
15	phosphorus	P
16	sulfur	S
17	chlorine	Cl
18	argon	Ar
19	potassium, (kalium)	K
20	calcium	Ca
21	scandium	Sc
22	titanium	Ti
23	vanadium	V
24	chromium	Cr
25	manganese	Mn
26	iron, (ferrum)	Fe
27	cobalt	Co
28	nickel	Ni
29	copper, (cuprum)	Cu
30	zinc	Zn
31	gallium	Ga
32	germanium	Ge
33	arsenic	As
34	selenium	Se
35	bromine	Br
36	krypton	Kr
37	rubidium	Rb
38	strontium	Sr
39	yttrium	Y
40	zirconium	Zr
41	niobium	Nb
42	molybdenum	Mo

Atomic number	Name	Symbol
43	technetium	Tc
44	ruthenium	Ru
45	rhodium	Rh
46	palladium	Pd
47	silver, (argentum)	Ag
48	cadmium	Cd
49	indium	In
50	tin, (stannum)	Sn
51	antimony, (stibium)	Sb
52	tellurium	Te
53	iodine	I
54	xenon	Xe
55	caesium	Cs
56	barium	Ba
57	lanthanum	La
58	cerium	Ce
59	praseodymium	Pr
60	neodymium	Nd
61	promethium	Pm
62	samarium	Sm
63	europium	Eu
64	gadolinium	Gd
65	terbium	Tb
66	dysprosium	Dy
67	holmium	Ho
68	erbium	Er
69	thulium	Tm
70	ytterbium	Yb
71	lutetium	Lu
72	hafnium	Hf
73	tantalum	Ta
74	tungsten, (wolfram)	W
75	rhenium	Re
76	osmium	Os
77	iridium	Ir
78	platinum	Pt
79	gold, (aurum)	Au
80	mercury, (hydrargyrum)	Hg
81	thallium	Tl
82	lead, (plumbum)	Pb
83	bismuth	Bi
84	polonium	Po
85	astatine	At
86	radon	Rn

1) Quoted from: IUPAC, Physical Chemistry Division: Quantities, Units and Symbols in Physical Chemistry (1988). The names in parentheses are added for information.

Atomic number	Name	Symbol
87	francium	Fr
88	radium	Ra
89	actinium	Ac
90	thorium	Th
91	protactinium	Pa
92	uranium	U
93	neptunium	Np
94	plutonium	Pu
95	americium	Am
96	curium	Cm
97	berkelium	Bk
98	californium	Cf
99	einsteinium	Es
100	fermium	Fm
101	mendelevium	Md
102	nobelium	No
103	lawrencium	Lr
104	unnilquadium	Unq
105	unnilpentium	Unp
106	unnilhexium	Unh
107	unnilseptium	Uns
108	unniloctium	Uno
109	unnilennium	Une

Annex B
(normative)

Symbols for chemical elements and nuclides

Symbols for chemical elements shall be written in roman (upright) type. The symbol is not followed by a full stop.

EXAMPLES

H He C Ca

The attached subscripts or superscripts specifying a nuclide or molecule shall have the following meanings and positions.

The nucleon number (mass number) of a nuclide is shown in the left superscript position, for example

^{14}N

The number of atoms of a nuclide in a molecule is shown in the right subscript position, for example

$^{14}N_2$

The proton number (atomic number) may be indicated in the left subscript position, for example

$_{64}Gd$

If necessary, a state of ionization or an excited state may be indicated in the right superscript position.

EXAMPLES

State of ionization: Na^+, PO_4^{3-} or $(PO_4)^{3-}$

Electric excited state: He^*, NO^*

Nuclear excited state: $^{110}Ag^*$ or $^{110}Ag^m$

Annex C
(informative)

Original names and symbols for nuclides of radioactive series

(4n + 2)-series (uranium series) 4n-series (thorium series) (4n + 3)-series (actinium series)

Name	Old symbol	Symbol of nuclide	Name	Old symbol	Symbol of nuclide	Name	Old symbol	Symbol of nuclide
uranium I	U I	^{238}U	thorium	Th	^{232}Th	actinouranium	AcU	^{235}U
uranium X_1	U X_1	^{234}Th	mesothorium 1	$MsTh_1$	^{228}Ra	uranium Y	U Y	^{231}Th
uranium Z, uranium X_2	U Z, U X_2	^{234}Pa	mesothorium 2	$MsTh_2$	^{228}Ac	protoactinium	Pa	^{231}Pa
uranium II	U II	^{234}U	radiothorium	RdTh	^{228}Th	actinium	Ac	^{227}Ac
ionium	Io	^{230}Th	thorium X	Th X	^{224}Ra	radioactinium	RdAc	^{227}Th
radium	Ra	^{226}Ra	thoron	Tn	^{220}Rn	actinium K	Ac K	^{223}Fr
radon	Rn	^{222}Rn	thorium A	Th A	^{216}Po	actinium X	Ac X	^{223}Ra
radium A	Ra A	^{218}Po	thorium B	Th B	^{212}Pb	actinon	An	^{219}Rn
radium B	Ra B	^{214}Pb	thorium C	Th C	^{212}Bi	actinium A	Ac A	^{215}Po
radium C	Ra C	^{214}Bi	thorium C'	Th C'	^{212}Po	actinium B	Ac B	^{211}Pb
radium C'	Ra C'	^{214}Po	thorium C''	Th C''	^{208}Tl	actinium C	Ac C	^{211}Bi
radium C''	Ra C''	^{210}Tl	thorium D	Th D	^{208}Pb	actinium C'	Ac C'	^{211}Po
radium D	Ra D	^{210}Pb				actinium C''	Ac C''	^{207}Tl
radium E	Ra E	^{210}Bi				actinium D	Ac D	^{207}Pb
radium F (polonium)	Ra F	^{210}Po						
radium G	Ra G	^{206}Pb						

Annex D
(informative)

Examples of relations in different systems of equations

Item No.	Subject	Rationalized system of equations with four base quantities	Gaussian system of equations with three base quantities
1	Bohr radius	$a_0 = 4\pi\varepsilon_0\hbar^2/m_e e^2$	$a_0 = \hbar^2/m_e e_s^2$
2	Rydberg constant	$R_\infty = m_e e^4/(4\pi)^3\varepsilon_0^2\hbar^3 c$	$R_\infty = m_e e_s^4/4\pi\hbar^3 c$
3	Bohr magneton	$\mu_B = e\hbar/2m_e$	$\mu_{B,s} = e_s\hbar/2m_e c$
4	nuclear magneton	$\mu_N = e\hbar/2m_p$	$\mu_{N,s} = e_s\hbar/2m_p c$
5	relation between gyromagnetic coefficient and g-factor of nucleus	$\gamma = g\mu_N/\hbar = ge/2m_p$	$\gamma_s = g\mu_{N,s}/\hbar = ge_s/2m_p c$
6	Larmor angular frequency	$\omega_L = (e/2m_e)B$	$\omega_L = (e_s/2m_e c)B_s$
7	cyclotron angular frequency (of electron)	$\omega_c = (e/m_e)B$	$\omega_c = (e_s/m_e c)B_s$
8	fine-structure constant	$\alpha = e^2/4\pi\varepsilon_0\hbar c$	$\alpha = e_s^2/\hbar c$
9	electron radius	$r_e = e^2/4\pi\varepsilon_0 m_e c^2$	$r_e = e_s^2/m_e c^2$
10	Compton wavelength	$\lambda_C = h/mc = 2\pi\hbar/mc$	$\lambda_C = h/mc = 2\pi\hbar/mc$

Quantities occurring in the second column of equations which differ from the corresponding quantity in the first column of equations have a suffix s (symmetric). The values of some of the quantities expressed in CGS units of the Gaussian system (see the introduction to ISO 31-5:1992, subclause 0.5.2) are as follows:

$\mu_{B,s} = (9{,}274\,015\,4 \pm 0{,}000\,003\,1) \times 10^{-21}$ erg per gauss

$\mu_{N,s} = (5{,}050\,786\,6 \pm 0{,}000\,001\,7) \times 10^{-24}$ erg per gauss

$\gamma_{p,s} = (2{,}675\,221\,28 \pm 0{,}000\,000\,81) \times 10^4$ reciprocal second reciprocal gauss, where $\gamma_{p,s}$ is the Gaussian gyromagnetic coefficient γ_s of the proton.

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Descriptors: international system of units, units of measurement, quantities, symbols, definitions, conversion of units, conversion factor, atom physics.

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