INTERNATIONAL STANDARD

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Quantities and units —

Part 9:
Atomic and nuclear physics

Grandeurs et unités —

Partie 9: Physique atomique et nucléaire

Reference number
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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}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}C in the ground state	$m_u = (1{,}660\ 540\ 2 \pm 0{,}000\ 001\ 0) \times 10^{-27}$ kg [1)] $= 1$ u $\dfrac{m_a}{m_u}$ 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	$1\ u = (1{,}660\ 540\ 2 \pm 0{,}000\ 001\ 0) \times 10^{-27}$ 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).				
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).				
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).				
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).				
9-9	Rydberg constant	R_∞	$R_\infty = \dfrac{e^2}{8\pi\varepsilon_0 a_0 hc}$	$R_\infty = (1{,}097\ 373\ 153\ 4 \pm 0{,}000\ 000\ 001\ 3) \times 10^7\ \mathrm{m}^{-1}$ [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)]
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}		

1) CODATA Bulletin 63 (1986).