INTERNATIONAL STANDARD ISO 31/X

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION •МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ •ORGANISATION INTERNATIONALE DE NORMALISATION

Quantities and units of nuclear reactions and ionizing radiations

First edition — 1973-07-01

UDC 53.081

Ref. No. ISO 31/X-1973 (E)

Descriptors : nuclear reactions, ionizing radiation, units of measurement, symbols.

Price based on 15 pages

ISO 31/X-1973 (E)

FOREWORD

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO Member Bodies). The work of developing International Standards is carried out through ISO Technical Committees. Every Member Body interested in a subject for which a Technical Committee has been set up 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.

Draft International Standards adopted by the Technical Committees are circulated to the Member Bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 31/X (originally Draft International Standard ISO/DIS 839) was drawn up by Technical Committee ISO/TC 12, *Quantities, units, symbols, conversion factors and conversion tables.*

It was approved in May 1968 by the Member Bodies of the following countries :

Australia	India	South Africa, Rep. of
Belgium	Iraq	Spain
Brazil	Ireland	Sweden
Bulgaria	Israel	Switzerland
Czechoslovakia	Italy	Thailand
Denmark	Japan	Turkey
Egypt, Arab Rep. of	Korea, Dem. P. Rep. of	United Kingdom
Finland	Netherlands	U.S.A.
France	New Zealand	U.S.S.R.
Germany	Norway	Yugoslavia
Greece	Poland	
Hungary	Romania	

No Member Body expressed disapproval of the document.

Quantities and units of nuclear reactions and ionizing radiations

INTRODUCTION

General remarks

This document, containing a table of *quantities and units of nuclear reactions and ionizing radiations*, is the tenth part of a more comprehensive publication dealing with quantities of units in various fields of science and technology. The parts of this publication are :

Part 0 : *General principles concerning quantities, units and symbols.*[1]

Part I (2nd edition) : *Basic quantities and units of the SI and quantities and units of space and time.*[2]

Part II : *Quantities and units of periodic and related phenomena.*

Part III : *Quantities and units of mechanics.*

Part IV : *Quantities and units of heat.*

Part V : *Quantities and units of electricity and magnetism.*

Part VI : *Quantities and units of light and related electromagnetic radiations.*

Part VII : *Quantities and units of acoustics.*

Part VIII : *Quantities and units of physical chemistry and molecular physics.*

Part IX : *Quantities and units of atomic and nuclear physics.*

Part X : *Quantities and units of nuclear reactions and ionizing radiations.*

Part XI : *Mathematical signs and symbols for use in the physical sciences and technology.*

General information regarding the arrangement of the tables and the symbols and abbreviations used is to be found in the introduction to Part I, where the full definitions of base units are given as an appendix.

The statements in the definition column for quantities are given merely for identification; they are not intended to be complete definitions.

Special remarks

In this document the term "particle" includes particles having a rest mass as well as particles without rest mass.

Distribution functions in terms of energy, velocity, solid angle etc. correspond to several quantities listed in this document. The subscripts E, v and Ω are used as part of the symbol to indicate that the quantity has the dimension of a derivative with respect to E, v and Ω respectively. In general these distribution functions are only mentioned in the remarks column; see for example 10-10.1, 10-27.1, 10-29.1 and 10-30.1.

In the case of cross sections, some of these distribution functions are given special names and are listed as separate items.

Units

As the units of the CGS system are widely used in the field of atomic and nuclear physics, the CGS units for some of the "mechanical" quantities are given in addition to those of the International System of Units.

---

1) At present at the stage of draft (No. 2180).

2) The title of the first edition of this document was : "Fundamental quantities and units of the MKSA system and quantities and units of space and time".

10. Nuclear reactions and ionizing radiations

Item No.	Quantity	Symbol	Definition [1]	Remarks
10-1.1	reaction energy	Q	In a nuclear reaction, the sum of the kinetic and radiant energies of the reaction products minus the sum of the kinetic and radiant energies of the reactants.	For exothermic nuclear reactions $Q > 0$ For endothermic nuclear reactions $Q < 0$ For beta-disintegration, see ISO/R 31/Part IX, item 9-38.
10-2.1	resonance energy	E_r, E_{res}	The kinetic energy of an incident particle in the reference frame of the target, corresponding to a resonance in a nuclear reaction.	
10-3.1	cross section	σ	Area ascribed to a target particle such that the number of reactions or processes of a specified type which take place per target particle is equal to the number of incident particles entering a sphere of this cross sectional area.	The type of process is indicated with subscripts, e.g. absorption cross section σ_a, σ_A scattering cross section σ_s, σ_S fission cross section σ_f
10-3.2	total cross section	σ_{tot}, σ_T	The sum of all cross sections corresponding to the various reactions or processes between incident particle and target particle.	In the case of a narrow unidirectional beam of incident particles, this is the effective cross section for the removal of an incident particle from the beam. See remark to 10-12.1
10-4.1	angular cross section	σ_Ω	Cross section for ejecting or scattering a particle into an element of solid angle, divided by this element. $\sigma = \int \sigma_\Omega d\Omega$	The quantities 10-4.1, 10-5.1 and 10-6.1 are sometimes called differential cross sections. In accordance with conventions used in other parts of ISO/R 31 angular and spectral cross sections are indicated by the use of subscripts. The information about incoming and outgoing particles may be added between parentheses, e.g. $\sigma_{\Omega,E}(nE_o,pE\theta)$ or $\sigma_{\Omega,E}(nE_o;p)$ or $\sigma_{\Omega,E}(n;p)$.
10-5.1	spectral cross section	σ_E	Cross section for a process in which the energy of the ejected or scattered particle is in an element of energy, divided by this element. $\sigma = \int \sigma_E dE$	The cross section for a process in which an incoming neutron of energy E_o causes the ejection of a proton within the energy interval $(E, E+dE)$ and in the element of solid angle $d\Omega$, about the scattering angle θ is $\sigma_{\Omega,E}(nE_o,pE\theta) d\Omega dE$ Sometimes the incoming and outgoing particles are indicated by subscripts, in which case the subscripts Ω and/or E indicating the angular and/or spectral character could be placed in superscript position, e.g. $\sigma_{n,p}^{E,\theta}(E_o)$ or $\sigma_{n,p}^{E,\theta}$.
10-6.1	spectral angular cross section	$\sigma_{\Omega,E}$	Cross section for ejecting or scattering a particle into an element of solid angle with energy in an element of energy, divided by the product of these two elements. $\sigma = \iint \sigma_{\Omega,E} d\Omega dE$	If, however, the subscripts Ω and/or E are omitted completely from the cross section symbol, the angular and/or spectral character of the cross section then follows only from the occurrence of the variables θ and/or E for the outgoing particles between the parentheses, e.g. $\sigma_{n,p}(E_o,E\theta)$ or $\sigma_{n,p}(E\theta)$. These variables should then never be omitted.

[1] The statements in this column are given merely for identification and they are not intended to be complete definitions.

Item No.	Name of unit and in certain cases abbreviation for this name	International symbol for unit	Definition	Conversion factors	Remarks
10-1.a	joule	J			
10-1.b	erg	erg		$1 \text{ erg} = 10^{-7} \text{ J}$ (exactly)	
10-1.c	electronvolt	eV		$1 \text{ eV} = 1.602\,10 \times 10^{-19} \text{ J}$	See also ISO/R 31/Part III. The quantity 10-1.1 is usually expressed in electronvolts.
10-2.a	joule	J			
10-2.b	erg	erg		$1 \text{ erg} = 10^{-7} \text{ J}$ (exactly)	
10-2.c	electronvolt	eV		$1 \text{ eV} = 1.602\,10 \times 10^{-19} \text{ J}$	The quantity 10-2.1 is usually expressed in electronvolts.
10-3.a	square metre	m²			
10-3.b	square centimetre	cm²			
10-3.c	barn	b	$1 \text{ b} = 10^{-28} \text{ m}^2$	$1 \text{ b} = 10^{-28} \text{ m}^2$ (exactly)	
10-4.a	square metre per steradian	m²/sr			
10-4.b	square centimetre per steradian	cm²/sr			
10-4.c	barn per steradian	b/sr		$1 \text{ b/sr} = 10^{-28} \text{ m}^2/\text{sr}$ (exactly)	
10-5.a	square metre per joule	m²/J			
10-5.b	square centimetre per erg	cm²/erg		$1 \text{ cm}^2/\text{erg} = 10^3 \text{ m}^2/\text{J}$ (exactly)	
10-5.c	barn per electronvolt	b/eV		$1 \text{ b/eV} = 6.242\,20 \times 10^{-10} \text{ m}^2/\text{J}$	
10-6.a	square metre per steradian joule	m²/(sr·J)			
10-6.b	square centimetre per steradian erg	cm²/(sr·erg)		$1 \text{ cm}^2/(\text{sr·erg}) = 10^3 \text{ m}^2/(\text{sr·J})$ (exactly)	
10-6.c	barn per steradian electronvolt	b/(sr·eV)		$1 \text{ b/(sr·eV)} = 6.242\,20 \times 10^{-10} \text{ m}^2/(\text{sr·J})$	

Item No.	Quantity	Symbol	Definition [1]	Remarks
10-7.1	macroscopic cross section (cross section density)	Σ	The sum of the cross sections for a reaction or process of a specified type over all atoms in a given volume, divided by that volume.	$\Sigma = n_1\sigma_1 + ... + n_i\sigma_i + ...$ (n_i is the number density and σ_i is the cross section for atoms of type i). When the target particles of the medium are at rest $\Sigma = 1/l$, where l is the mean free path, see 10-37.1
10-7.2	total macroscopic cross section (total cross section density)	Σ_{tot}, Σ_T	The sum of total cross sections for all atoms in a given volume, divided by that volume.	See remark to 10-11.1
10-8.1	particle flux density	φ	At a given point in space, the number of particles incident on a small sphere in a time interval, divided by the cross sectional area of that sphere and by the time interval.	See also 10-29.1, where distribution functions are also included in the "Remarks" column. Also called particle fluence rate. Particle fluence is the time integral of the particle flux density. Usually the word particle is replaced by the name of a specific particle, e.g. proton flux density, proton fluence rate.
10-9.1	energy flux density	ψ	At a given point in space, the sum of the energies, exclusive of rest energy, of all the particles incident on a small sphere in a time interval, divided by the cross sectional area of that sphere and by the time interval.	Also called energy fluence rate. Energy fluence is the time integral of the energy flux density.
10-10.1	current density of particles	J, (S)	A vector quantity the integral of whose normal component over any surface is equal to the current of particles through that surface.	S is recommended when there is a possibility of confusion with the symbol J for electric current density. For neutron current density the symbol J is generally used. The distribution functions in terms of speed and energy, J_v and J_E, are related to J by $$J = \int J_v\,dv = \int J_E\,dE$$
10-11.1	linear attenuation coefficient	μ, μ_1	$dJ/dx = -\mu J$ where J is the current density of a beam of particles parallel to the x-direction.	μ is equal to the total macroscopic cross section Σ_{tot} for removal of particles from the beam.
10-12.1	atomic attenuation coefficient	μ_a, μ_{at}	$\mu_a = \mu/n$ where n is the number density of atoms in the substance. (See also 10-25.1)	μ_a is equal to the total cross section σ_{tot} for removal of particles from the beam.
10-13.1	mass attenuation coefficient	μ/ϱ, μ_m	The linear attenuation coefficient divided by the mass density of the substance.	
10-14.1	half-thickness, half value thickness	$d_{1/2}$	The thickness of the attenuating layer that reduces the current density of a unidirectional beam to one-half of its initial value.	For exponential attenuation $d_{1/2} = (\ln 2)/\mu$

[1] See footnote on page 2.

Item No.	Name of unit and in certain cases abbreviation for this name	International symbol for unit	Definition	Conversion factors	Remarks
10-7.a	reciprocal metre	m⁻¹			
10-7.b	reciprocal centimetre	cm⁻¹			
10-8.a	reciprocal second reciprocal square metre	$s^{-1} \cdot m^{-2}$			
10-8.b	reciprocal second reciprocal square centimetre	$s^{-1} \cdot cm^{-2}$			
10-9.a	watt per square metre	W/m²			
10-9.b	erg per square centimetre second	erg/(cm² · s)			
10-9.c	electronvolt per square centimetre second	eV/(cm² · s)		$1 \text{ eV/(cm}^2 \cdot s) = 1.60210 \times 10^{-18} \text{ W/m}^2$	
10-10.a	reciprocal square metre reciprocal second	$m^{-2} \cdot s^{-1}$			
10-10.b	reciprocal square centimetre reciprocal second	$cm^{-2} \cdot s^{-1}$			
10-11.a	reciprocal metre	m⁻¹			
10-11.b	reciprocal centimetre	cm⁻¹			
10-12.a	square metre	m²			
10-12.b	square centimetre	cm²			
10-13.a	square metre per kilogramme	m²/kg			
10-13.b	square centimetre per gramme	cm²/g			
10-14.a	**metre**	m			
10-14.b	centimetre	cm			

5

Item No.	Quantity	Symbol	Definition [1]	Remarks
10-15.1	linear stopping power	S, S_1	For an ionizing charged particle of energy E moving in the x-direction $S = - \, dE/dx$.	Also called stopping power. Both collision losses and radiation losses are included. The ratio of the linear stopping power of a substance to that of a reference substance is called relative linear stopping power. See also 10-51.1.
10-16.1	atomic stopping power	S_a	$S_a = S/n$ where n is the number density of atoms in the substance.	
10-17.1	mass stopping power	$S/\varrho, (S_m)$	The linear stopping power divided by the mass density of the substance.	The ratio of the mass stopping power of a substance to that of a reference substance is called relative mass stopping power.
10-18.1	stopping equivalent	d_{eq}	The stopping equivalent for a given thickness of a substance is that thickness of a standard substance that produces the same energy loss.	When air is taken as standard substance then it should be air at 15°C and 1 atm.
10-19.1	mean linear range	R, R_1	The average distance that a particle penetrates a given substance under specified conditions.	
10-20.1	mean mass range	$R\varrho, (R_m)$	The mean linear range multiplied by the mass density of the substance.	
10-21.1	linear ionization of a particle	N_{il}	The number of elementary charges of one sign produced over an element of length of the path of an ionizing charged particle, divided by that element.	Ionizing due to secondary ionizing particles etc. is included.
10-22.1	total ionization of a particle	N_i	The total number of elementary charges of one sign produced by an ionizing charged particle along its entire path.	This quantity is dimensionless. $N = \int N_{il} dl$ See remark to 10-21.1.
10-23.1	average energy loss per ion pair formed	W_i	The initial kinetic energy of an ionizing charged particle, divided by the total ionization of that particle.	The quantity S_l/N_{il}, sometimes called average energy per ion pair formed, should not be confused with W_i.

1) See footnote on page 2.

Item No.	Name of unit and in certain cases abbreviation for this name	International symbol for unit	Definition	Conversion factors	Remarks
10-15.a	joule per metre	J/m			
10-15.b	erg per centimetre	erg/cm		1 erg/cm $=$ 10^{-5} J/m (exactly)	
10-15.c	electronvolt per centimetre	eV/cm		1 eV/cm $=$ 1.602 10 $\times 10^{-17}$ J/m	The quantity 10-15.1 is usually expressed in kiloelectronvolts per micrometre (keV/µm)
10-16.a	joule square metre	J · m²			
10-16.b	erg square centimetre	erg · cm²		1 erg · cm² $=$ 10^{-11} J · m² (exactly)	
10-16.c	electronvolt square centimetre	eV · cm²		1 eV · cm² $=$ 1.602 10 $\times 10^{-23}$ J · m²	
10-17.a	joule square metre per kilogramme	J · m²/kg			
10-17.b	erg square centimetre per gramme	erg · cm²/g		1 erg · cm²/g $=$ 10^{-4} J · m²/kg (exactly)	
10-17.c	electronvolt square centimetre per gramme	eV · cm²/g		1 eV · cm²/g $=$ 1.602 10 $\times 10^{-20}$ J · m²/kg	The quantity 10-17.1 is usually expressed in MeV · cm²/g $=$ keV · cm²/mg
10-18.a	metre	m			
10-18.b	centimetre	cm			
10-19.a	metre	m			
10-19.b	centimetre	cm			
10-20.a	kilogramme per square metre	kg/m²			
10-20.b	gramme per square centimetre	g/cm²			
10-21.a	reciprocal metre	m⁻¹			
10-21.b	reciprocal centimetre	cm⁻¹			
10-23.a	joule	J			
10-23.b	erg	erg		1 erg $=$ 10^{-7} J (exactly)	
10-23.c	electronvolt	eV		1 eV $=$ 1.602 10 $\times 10^{-19}$ J	The quantity 10-23.1 is usually expressed in electronvolts.

Item No.	Quantity	Symbol	Definition 1)	Remarks
10-24.1	mobility	b, μ	The average drift velocity imparted to a charged particle in a medium by an electric field, divided by the field strength.	
10-25.1	ion number density, ion density	n^+, n^-	The number of positive or negative ions in an element of volume, divided by that element.	n is the general symbol for number density of particles.
10-26.1	recombination coefficient	α	Coefficient in the law of recombination $$-\frac{dn^+}{dt} = -\frac{dn^-}{dt} = \alpha n^+ n^-$$	
10-27.1	neutron number density	n	The number of neutrons in an element of volume, divided by that volume.	The distribution functions in terms of speed and energy n_v and n_E are related to n by $$n = \int n_v \, dv = \int n_E \, dE$$
10-28.1	neutron speed	v	The magnitude of the neutron velocity.	
10-29.1	neutron flux density	φ	At a given point in space, the number of neutrons incident on a small sphere in a time interval, divided by the cross sectional area of that sphere and by the time interval.	See also 10-8.1 The distribution functions in terms of speed and energy φ_v and φ_E are related to φ by $$\varphi = \int \varphi_v \, dv = \int \varphi_E \, dE$$ $$\varphi_v = n_v v \text{ and } \varphi = n \langle v \rangle$$ where $\langle v \rangle$ is the average neutron speed. φ is sometimes called neutron flux.
10-30.1	diffusion coefficient, diffusion coefficient for neutron number density	D, D_n	$J_x = -D_n \, \partial n / \partial x$ where J_x is the x-component of the neutron current density and n is the number density of neutrons.	The distribution function in terms of speed $J_{v,x}$ is related to J_x by $$J_x = \int J_{v,x} \, dv$$
10-31.1	diffusion coefficient for neutron flux density	D_φ, (D)	$J_x = -D_\varphi \, \partial \varphi / \partial x$ where J_x is the x-component of the neutron current density and φ is the neutron flux density.	For neutrons of a given speed $$J_{v,x} = -D_n(v) \partial n_v / \partial x$$ $$= -D_\varphi(v) \partial \varphi_v / \partial x$$ where $v D_\varphi(v) = D_n(v)$
10-32.1	total neutron source density	S	The rate of production of neutrons in an element of volume, divided by that element.	The distribution functions in terms of speed and energy S_v and S_E are related to S by $$S = \int S_v \, dv = \int S_E \, dE$$

1) See footnote on page 2.

Item No.	Name of unit and in certain cases abbreviation for this name	International symbol for unit	Definition	Conversion factors	Remarks
10-24.a	square metre per volt second	$m^2/(V \cdot s)$			
10-25.a	reciprocal cubic metre	m^{-3}			
10-25.b	reciprocal cubic centimetre	cm^{-3}			
10-26.a	cubic metre per second	m^3/s			
10-26.b	cubic centimetre per second	cm^3/s			
10-27.a	reciprocal cubic metre	m^{-3}			
10-27.b	reciprocal cubic centimetre	cm^{-3}			
10-28.a	metre per second	m/s			
10-28.b	centimetre per second	cm/s			
10-29.a	reciprocal second reciprocal square metre	$s^{-1} \cdot m^{-2}$			
10-29.b	reciprocal second reciprocal square centimetre	$s^{-1} \cdot cm^{-2}$			
10-30.a	square metre per second	m^2/s			
10-30.b	square centimetre per second	cm^2/s			
10-31.a	metre	m			
10-31.b	centimetre	cm			
10-32.a	reciprocal second reciprocal cubic metre	$s^{-1} \cdot m^{-3}$			
10-32.b	reciprocal second reciprocal cubic centimetre	$s^{-1} \cdot cm^{-3}$			

9

Item No.	Quantity	Symbol	Definition [1]	Remarks
10-33.1	slowing down density	q	The number density of neutrons slowing down past a given energy value during a small time interval, divided by that time interval.	
10-34.1	resonance escape probability	p	The probability that a neutron in a slowing down process without leakage will traverse the resonance energy range without being absorbed.	This quantity is dimensionless.
10-35.1	lethargy	u	The lethargy of a neutron of energy E is defined as $$u = \ln (E_0/E)$$ where E_0 is a reference energy.	This quantity is dimensionless.
10-36.1	average logarithmic energy decrement	ξ	The average value of the increase in lethargy in a neutron collision.	This quantity is dimensionless.
10-37.1	mean free path	l, λ	The average distance which a particle travels between two successive specified reactions or processes.	See remark 10-7.1.
10-38.1	slowing down area	L_s^2, L_{s1}^2	In an infinite homogeneous medium, one sixth of the mean square distance between the source of a neutron and the point where the neutron reaches a given energy.	When the Fermi age theory is applicable this quantity is equal to the "Fermi age", τ.
10-38.2	diffusion area	L^2	In an infinite homogeneous medium, one sixth of the mean square distance between the point where a neutron enters a specified class and the point where it leaves this class.	
10-38.3	migration area	M^2	The sum of the slowing down area from fission energy to thermal energy and the diffusion area for thermal neutrons.	
10-39.1	slowing down length	L_s, L_{s1}	The square root of the slowing down area.	
10-39.2	diffusion length	L	The square root of the diffusion area.	
10-39.3	migration length	M	The square root of the migration area.	
10-40.1	neutron yield per fission	ν	The average number of neutrons, both prompt and delayed, emitted per neutron fission.	These quantities are dimensionless.
10-40.2	neutron yield per absorption	η	The average number of fission neutrons produced per neutron absorbed in fuel material.	η/ν is equal to the ratio of the macroscopic cross section for fission to that for absorption, both for neutrons in the fuel material.
10-41.1	fast fission factor	ε	The ratio of the number of fission neutrons due to neutrons of all energies, to that due to thermal neutrons only.	This quantity is dimensionless.

[1] See footnote on page 2.

10

Item No.	Name of unit and in certain cases abbreviation for this name	International symbol for unit	Definition	Conversion factors	Remarks
10-33.a	reciprocal second reciprocal cubic metre	$s^{-1} \cdot m^{-3}$			
10-33.b	reciprocal second reciprocal cubic centimetre	$s^{-1} \cdot cm^{-3}$			
10-37.a	metre	m			
10-37.b	centimetre	cm			
10-38.a	metre squared	m^2			
10-38.b	centimetre squared	cm^2			
10-39.a	metre	m			
10-39.b	centimetre	cm			

Quantities
10-42.1...10-49.1

Item No.	Quantity	Symbol	Definition 1)	Remarks
10-42.1	thermal utilization factor	f	The ratio of the number of thermal neutrons absorbed in fuel material to the total number of thermal neutrons absorbed.	This quantity is dimensionless.
10-43.1	non-leakage probability	Λ	The probability that a neutron will not escape from the reactor during the slowing down process or while it diffuses as a thermal neutron.	This quantity is dimensionless.
10-44.1	multiplication factor	k	The ratio of the total number of fission or fission dependent neutrons produced during a time interval to the total number of neutrons lost by absorption and leakage during the same interval.	These quantities are dimensionless.
10-44.2	infinite medium multiplication factor	k_∞	The multiplication factor for an infinite medium or for an infinite repeating lattice.	For a thermal reactor: $k_\infty = \eta \varepsilon p f$
10-44.3	effective multiplication factor	k_{eff}	The multiplication factor for a finite medium.	
10-45.1	reactivity	ϱ	$\varrho = \dfrac{k_{eff} - 1}{k_{eff}}$	This quantity is dimensionless.
10-46.1	reactor time constant	T	The time required for the neutron flux density in a reactor to change by the factor e when the flux density is rising or falling exponentially.	Also called reactor period.
10-47.1	activity	A	The number of nuclear transformations or transitions occurring in a certain amount of a radionuclide or in a radioactive source in a small time interval, divided by that interval.	Values given for activities are not always unambiguous unless the radionuclide or the radioactive source and the type of transformation or transition are specified.
10-48.1	energy imparted	E_D	The energy imparted by ionizing radiation to the matter in a volume is the difference between the sum of the energies of all the directly ionizing (charged) and indirectly ionizing (uncharged) particles which have entered the volume and the sum of the energies of all those which have left it, minus the energy equivalent of any increase in rest mass that took place in nuclear or elementary particle reactions within the volume.	$E_D = \int D\, dm$ where dm is an element of mass of the irradiated matter. Also called integral absorbed dose.
10-49.1	absorbed dose	D	For any ionizing radiation, the energy imparted to an element of irradiated matter, divided by the mass of this element.	

1) See footnote on page 2.

Item No.	Name of unit and in certain cases abbreviation for this name	International symbol for unit	Definition	Conversion factors	Remarks
10-46.a	**second**	s			
10-47.a	reciprocal second	s^{-1}			
10-47.b	curie	Ci	$1 \text{ Ci} = 3.7 \times 10^{10} \text{ s}^{-1}$	$1 \text{ Ci} = 3.7 \times 10^{10} \text{ s}^{-1}$ (exactly)	
10-48.a	joule	J			The special unit, gramme rad, for the quantity 10-48.1 is defined by $1 g \cdot rad = 10^{-5} J = 100$ erg
10-48.b	erg	erg			
10-49.a	joule per kilogramme	J/kg			The special unit, rad, for the quantity 10-49.1 is defined by $1 \text{ rad} = 10^{-2} \text{ J/kg} = 10^{2}$ erg/g
10-49.b	erg per gramme	erg/g			

Quantities
10-50.1...10-57.1

Item No.	Quantity	Symbol	Definition [1]	Remarks
10-50.1	absorbed dose rate	$\dot{D}$	Absorbed dose in a small time interval divided by that interval.	$\dot{D} = \dfrac{dD}{dt}$
10-51.1	linear energy transfer	L	For an ionizing charged particle, the energy locally imparted to matter in traversing a small distance, divided by that distance.	This quantity is not completely defined unless the limits involved in the term "locally imparted energy" are specified; e. g. energy transfers in collisions below a specified maximum may be considered.
10-52.1	kerma	K	For indirectly ionizing (uncharged) particles, sum of the initial kinetic energies of all charged particles liberated in an element of matter, divided by the mass of that element.	The name kerma is derived from Kinetic Energy Released in MAtter.
10-53.1	kerma rate	$\dot{K}$	Kerma in a certain time interval, divided by that interval.	$\dot{K} = \dfrac{dK}{dt}$
10-54.1	mass energy transfer coefficient	$\mu_{mk}, \mu_K/\varrho$	For a beam of indirectly ionizing (uncharged) particles $$\mu_K/\varrho = \frac{\dot{K}}{\psi}$$ where ψ is the energy flux density.	The quantity $(\mu_K/\varrho)(1-G)$, where G is the fraction of the energy of the secondary charged particles that is lost to Bremsstrahlung, is called mass energy absorption coefficient. See also 10-13.1.
10-55.1	exposure, (ionization exposure)	X	For X- or gamma radiation, the total electric charge of the ions of one sign, produced when all the electrons liberated by photons in an element of air are stopped in air, divided by the mass of that element.	The ionization arising from the absorption of Bremsstrahlung emitted by the secondary electrons liberated in the element is not included. This quantity should not be confused with the quantity radiant exposure, see 6-25.1. For any ionizing radiation the total electric charge of the ions of one sign produced in an element of air divided by the mass of that element is called ion dose.
10-56.1	exposure rate, (ionization exposure rate)	$\dot{X}$	Ionization exposure in a certain time interval, divided by that interval.	$\dot{X} = \dfrac{dX}{dt}$
10-57.1	specific gamma ray constant	Γ	For a nuclide emitting gamma radiation $$\Gamma = \frac{a^2 \dot{X}}{A}$$ where $\dot{X}$ is the exposure rate which would exist at a distance a from a point source of this nuclide having the activity A, if there were no attenuation of the gamma radiation along the intervening path.	For activity, see 10-47.1.

[1] See footnote on page 2.

14