



Standard Terminology for Radiochemical Analyses¹

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1. Scope

1.1 This standard describes terminology commonly used in radiochemistry and radioanalysis.

1.2 The values stated in SI units are to be regarded as standard. Other units of measurement, including some units that are not accepted for use with the SI, are also defined.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*²

[D7282 Practice for Set-up, Calibration, and Quality Control of Instruments Used for Radioactivity Measurements](#)

2.2 *International Bureau of Weights and Measures Documents:*³

[GUM Guide to the Expression of Uncertainty in Measurement \(GUM\), 100:2008](#)

2.3 *Code of Federal Regulations Documents:*⁴

[40 CFR 141.25 Analytical Methods for Radioactivity](#)
[40 CFR Appendix B to Part 136 Definition and Procedure for the Determination of the Method Detection Limit](#)

2.4 *ANSI Documents:*⁵

[ANSI N42.22 Traceability of Radioactive Sources to the National Institute of Standards and Technology \(NIST\) and Associated Instrument Quality Control](#)

¹ This terminology is under the jurisdiction of ASTM Committee D19 on Water and is the direct responsibility of Subcommittee D19.04 on Methods of Radiochemical Analysis.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

³ Available from Bureau International des Poids et Mesures (BIPM), Pavillon de Breteuil F-92312 Sèvres Cedex, France, <http://www.bipm.org>.

⁴ Available from U.S. Government Printing Office Superintendent of Documents, 732 N. Capitol St., NW, Mail Stop: SDE, Washington, DC 20401, <http://www.access.gpo.gov>.

⁵ Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, <http://www.ansi.org>.

3. Significance and Use

3.1 This terminology standard describes terms and definitions used in standards for radiochemical analysis maintained by ASTM Committee D19 on Water. The terminology is also recommended for general use in the radiochemistry community.

4. Terminology: Terms and Definitions

4 π geometry, *n*—geometry in which the radiation detector has essentially the same probability of detecting radiation from the source emitted in any direction.

absorption (of radiation), *n*—transfer of some or all of the energy of a radiation to matter it traverses.

abundance, (*I*) *n*—probability of emission of a given radiation during the decay of an atom of a given radionuclide; radiation emission probability—also called *intensity*;
(2) see **isotopic abundance**.

actinide, *n*—any element with atomic number between 89 and 103, including actinium, thorium, protactinium, uranium, neptunium, plutonium, americium, and curium.

activation, *n*—inducement of radioactivity by irradiation.

activation analysis, *n*—analysis based on the characteristic radiations emitted by nuclides formed by activation.

activity (for radionuclides), *A* [T^{-1}], *n*—mean rate of radioactive decay in a quantity of material.

DISCUSSION—The term *activity* may be qualified by specifying one or more radionuclides (for example, ²³⁸U activity) or the type of decay (for example, gross alpha activity).

DISCUSSION—The SI unit of activity is the becquerel (Bq), which equals 1 s⁻¹ (one nuclear disintegration per second).

activity concentration, (*I*) *n*—quotient of the activity of a specified quantity of material and its volume; **volumic activity**;

(2) *n*—quotient of the activity of a specified quantity of material and its associated mass or size.

aliquant, *n*—fractional part that does not evenly divide the whole.

aliquot, *n*—fractional part that evenly divides the whole.

DISCUSSION—Chemists commonly use the term aliquot to mean either an aliquant or aliquot of a sample.

alpha decay, *n*—radioactive decay accompanied by the emission of an alpha particle.

alpha particle, α particle, *n*—particle consisting of two protons and two neutrons (a ^4He nucleus) emitted from a nucleus during certain types of radioactive decay.

alpha-particle spectrometry, alpha spectrometry, *n*—measurement of components of a sample or system based on analysis of alpha-particle spectra.

DISCUSSION—In titles and summaries, the full name alpha-particle spectrometry is preferred. In other contexts, either name is often acceptable.

alpha scintillation cell, *n*—specially designed sealable container, whose walls are coated with silver-activated zinc sulfide (a scintillator), having a transparent window at one end, which can be filled with a gas such as helium or nitrogen containing some quantity of radon and used in conjunction with a scintillation counter to measure the alpha emissions of the radon and its progeny.

analyst, *n*—person who performs analyses.

analyte, *n*—in an analysis, the component analyzed for.

ancestor (radionuclide), parent (radionuclide), *n*—radionuclide that produces a given nuclide in a series of one or more radioactive decays.

DISCUSSION—The term *ancestor* is often used in the context of indirect relationships involving a series of decays. The term *parent* is often used when there is a direct relationship.

annihilation, *n*—interaction between a particle and its antiparticle in which the original particles disappear and new photons or particles are produced.

annihilation peak, *n*—peak in a gamma-ray spectrum at 511 keV produced by annihilations of positrons and electrons.

DISCUSSION—Each annihilation results in two 511 keV gamma-rays, at least one of which usually escapes from the detector without depositing its energy.

anticoincidence counting, *n*—radiometric counting technique that lowers interference levels by rejecting any event that is accompanied by one or more other events occurring within a specified time interval.

DISCUSSION—Anticoincidence counting requires two or more detectors, often of different types, operating simultaneously.

areic, *adj*—in proportion to area.

DISCUSSION—The adjective *areic*, when applied to the name of a measurable quantity, indicates the quotient of that quantity and its associated area, as in *areic activity* or *areic mass*.

attenuation (of radiation), *n*—decrease in intensity of radiation due to interactions with matter.

attenuation coefficient, linear attenuation coefficient, μ or μ_l [L^{-1}], *n*—for a parallel beam of photons passing through a material, the fraction of the photons removed in a short distance, divided by that distance (see also **mass attenuation coefficient**).

DISCUSSION—The concept of an *attenuation coefficient* may be applied to other types of radiation provided the attenuation follows approximately an exponential law.

attenuation curve, *n*—plot of attenuation factors versus another quantity such as distance, mass, or areic mass.

attenuation factor, *n*—fraction of a beam of radiation remaining after the beam has passed through a given amount of material.

Auger effect, *n*—ejection of an electron, called an *Auger electron*, from an outer shell, accompanying the filling of a vacancy in an inner shell.

DISCUSSION—The Auger effect and X-ray emission are alternative means of releasing energy when such an inner shell vacancy is filled.

Auger electron, *n*—orbital electron ejected from an atom in the Auger effect.

background, (1) *n*—in general, the normal analyte concentration, radiation level, or instrument signal observed in the absence of the analyte or in the absence of any analyte contributed by a given cause;

(2) *n*—instrument signal observed in the absence of a source (also *instrument background* or *detector background*).

DISCUSSION—The unqualified term *background* has so many shades of meaning that it can be a source of confusion unless it is explained.

background subtraction count, BSC, *n*—a source count used to determine the background to be subtracted from the sample test source count. **D7282**

backscatter(ing), *n*—deflection of radiation by matter at any angle greater than 90° from its original direction of motion.

backscatter peak, *n*—peak in a gamma-ray spectrum produced by photons resulting from Compton scattering in the material surrounding the detector.

baseline, *n*—in the graph of a spectrum, the straight or curving line on which peaks are superimposed.

becquerel, Bq, *n*—special name for the SI derived unit of activity, equal to 1 s^{-1} (one nuclear disintegration per second).

beta decay, β decay, *n*—radioactive decay that results in a change in atomic number but no change in mass number; β^- decay, β^+ decay, or electron capture.

β^- decay, *n*—radioactive decay accompanied by the emission of a β^- particle and an antineutrino.

β^+ decay, *n*—radioactive decay accompanied by the emission of a β^+ particle and a neutrino.

beta particle, β particle, *n*—electron (β^-) or positron (β^+) emitted from a nucleus during certain types of radioactive decay.

bias (voltage), *n*—for many types of radiation detector, a voltage applied to the detector to enable it to detect an ionizing event.

blank, (1) *adj*—containing little or no analyte; analyte-free;
(2) see **blank sample**.

blank sample, *n*—any of various types of real or artificial samples that are expected to contain little or no analyte, such as a method blank or reagent blank.

DISCUSSION—Use of the term *blank sample* without qualification or explanation may cause confusion.

blank source, *n*—source prepared to simulate a test source with no analyte present.

branching decay, *n*—radioactive decay that can proceed in more than one way.

branching fraction, branching ratio, *n*—in branching decay, the fraction of nuclei that decay in a specified way.

calibration source, CS, *n*—a known quantity of radioactive material, traceable to a national standards body, prepared for the purpose of calibrating nuclear instruments. **D7282**

carrier, *n*—an isotope or mixture of isotopes of an element, chemically identical or similar to the radionuclide(s) of interest, added in a quantity sufficient to promote a desired chemical behavior and move the radionuclide(s) or an unwanted contaminant through a chemical process.

DISCUSSION—In radiochemistry the use of a carrier may also allow gravimetric measurement of the chemical yield.

cascade summing, (true) coincidence summing, *n*—summing produced when the energies of two or more radiations emitted by the same atom are absorbed by the detector within a period of time shorter than the resolving time of the detector.

Čerenkov counting, *n*—radiation counting technique based on detection of Čerenkov radiation (also *Cerenkov* or *Cherenkov*).

Čerenkov radiation, *n*—electromagnetic radiation emitted by a charged particle moving through a medium at a speed greater than the speed of light in that medium (also *Cerenkov* or *Cherenkov*).

channel, *n*—any of the data registers or memory locations used to record pulses in a single-channel or multichannel analyzer.

chemical yield, *n*—fraction of the amount of a given analyte or other substance remaining after specified chemical separations (sometimes called *recovery* or *chemical recovery*).

DISCUSSION—Use of the term *recovery* as a synonym for *chemical yield* may cause confusion and should be avoided. See **recovery**.

chemiluminescence, *n*—emission of electromagnetic radiation as a result of a chemical reaction – a possible cause of interference in liquid scintillation counting.

coincidence counting, *n*—radiometric counting technique that lowers interferences by rejecting any event that is not accompanied by one or more other events occurring within

a specified time interval; for example, coincidence counting of the beta particle and 364.5 keV gamma-ray from the decay of ¹³¹I.

DISCUSSION—Coincidence counting requires two or more detectors, often of different types, operating simultaneously.

combined standard uncertainty, u_c , *n*—standard uncertainty of a measurement result obtained by uncertainty propagation.

Compton baseline, *n*—baseline in a gamma-ray spectrum, which is due largely to Compton scattering but also in part to tailing and other effects.

Compton edge, *n*—feature of a gamma-ray spectrum which appears as an abrupt decrease in the baseline at the upper end of the energy distribution of the Compton electrons associated with a gamma-ray photopeak.

DISCUSSION—The Compton edge is found at the energy

$$E_{\gamma}^2 / (E_{\gamma} + m_e c^2 / 2)$$

where E_{γ} is the energy of the photopeak.

Compton effect, Compton scattering, *n*—scattering of a photon by a free or weakly bound electron in which the incident photon imparts a portion of its energy and momentum to the electron, resulting in a free electron and a scattered lower-energy photon.

Compton electron, *n*—the energetic free electron resulting from the Compton effect.

Compton photon, *n*—the scattered photon resulting from the Compton effect.

conversion electron, *n*—the orbital electron ejected from an atom by internal conversion.

coprecipitation, *n*—precipitation of a normally soluble component by inclusion in the precipitate of another less soluble component from the same solution.

cosmic radiation, *n*—radiation that originates outside Earth's atmosphere.

count, (1) *v*—to perform a radiation counting measurement;
(2) *n*—a radiation counting measurement;
(3) *n*—a single pulse registered during counting;
(4) *n*—total number of pulses registered during counting.

counting efficiency—see **detection efficiency**.

counting period, counting interval, *n*—time interval from the beginning to the end of a radiation counting measurement.

counting uncertainty, *n*—in radiochemistry, the uncertainty of the result of a measurement due to the random nature of radioactive decay, radiation emission, and radiation detection—also called *counting error*.

DISCUSSION—The term *counting uncertainty* is preferred because of the emphasis in metrology on the distinction between *error of measurement* and *uncertainty of measurement*.

count rate, *n*—quotient of the total count and the live time for a radiation counting measurement.

DISCUSSION—If the count rate is corrected by subtracting a background or blank value, it is called a *net count rate*. The uncorrected count rate may be called the *gross count rate*.

counts per minute, *n*—unit for count rate, equal to 1 min^{-1} .

DISCUSSION—The reciprocal minute (symbol min^{-1}) is accepted for use with the SI as a unit for count rate; however, the symbol cpm, which has sometimes been used, is not accepted for use with the SI.

counts per second, *n*—unit for count rate, equal to 1 s^{-1} .

DISCUSSION—The SI symbol for this unit is s^{-1} . The symbol cps, which has sometimes been used, is not accepted for use with the SI.

count time, counting time, count duration, *n*—either live time or real time, but often presumed to denote the live time.

DISCUSSION—In contexts where the difference between the two meanings is important, the more specific term is preferred to avoid any ambiguity.

coverage factor, *k, n*—factor by which a standard uncertainty is multiplied to obtain an expanded uncertainty.

critical value, (*I*) *n*—threshold value that a measurement result must exceed in order to lead to the decision that the analyte is present; detection threshold—also called *critical level* or *decision level*;

(2) *n*—in a statistical hypothesis test, a limiting value of the critical region for the test statistic.

crosstalk, *n*—phenomenon in gas proportional counting or liquid scintillation counting where an emitted alpha particle is misidentified as a beta particle or vice versa.

curie, Ci, *n*—traditional non-SI unit of activity, equal to $3.7 \times 10^{10} \text{ Bq}$, which is approximately the activity of one gram of pure ^{226}Ra .

DISCUSSION—The curie may be used with SI prefixes.

DISCUSSION—The curie is such a large unit that its submultiples (from the picocurie to the millicurie) are more commonly used as units for laboratory analyses.

daughter (nuclide), daughter product, descendant (nuclide), decay product, *n*—nuclide produced from a given radionuclide in a series of one or more radioactive decays.

DISCUSSION—The term *descendant* is often used in the context of indirect relationships involving a series of radioactive decays. The term *daughter* is often used when there is a direct relationship.

dead time, (*I*) *n*—time required for a radiation counter to process an event, during which additional events cannot be processed, generally expressed in terms of absolute time (for example, 10 s); cf. **resolving time**;

(2) see **total dead time**.

dead water, *n*—water devoid of tritium (for example, fossil water).

decay chain, *n*—sequence of nuclides arranged so that each nuclide after the first is an immediate decay product of its predecessor in the sequence.

decay constant, radioactive decay constant, $\lambda[\text{T}^{-1}]$, *n*—physical constant associated with a radionuclide, equal to the radionuclide's mean instantaneous fractional decay rate,

or for a single atom, the probability of decay during a short time interval, divided by the length of the interval.

DISCUSSION—The decay constant λ also equals $(\ln 2)/T_{1/2}$, where $T_{1/2}$ is the half-life of the radionuclide.

DISCUSSION—The activity of a collection of N atoms of the radionuclide equals λN .

decay factor, *n*—expected fraction of the atoms of a radionuclide remaining after a specified time, or for a single atom the probability of survival for a specified time.

decay scheme, *n*—graphical representation of the transitions that can occur during the decay of an atomic nucleus.

depleted uranium, DU, *n*—uranium in which the isotopic abundance of ^{235}U is less than its natural abundance (cf. **enriched uranium**).

delayed coincidence counting, *n*—radiometric counting technique that lowers interferences by accepting only an event that is accompanied by one or more other events occurring within a specified short but measurable time interval following the initial event; for example, delayed coincidence counting of the alpha particle from the decay of ^{220}Rn followed by the alpha particle from the decay of ^{216}Po (0.148 second half-life) – the immediate decay progeny.

DISCUSSION—Delayed coincidence counting may require the use of only one detector and is most advantageous where the detection efficiency of the initial and follow-on event is relatively high. The overall count rate must also be sufficiently low to minimize occurrence of accidental delayed coincidences.

desiccator, *n*—container used to dry material or keep it dry, usually by enclosing it in a small space with a desiccant.

detect, (*I*) *v*—(radiation) to produce an indication of an emitted ray or particle;

(2) *v*—(analyte) to determine by measurement that an analyte is present (for example, in a source or sample).

detection capability, *n*—ability of a measurement process to discriminate between small positive amounts of an analyte and zero—typically described by the minimum detectable value.

detection efficiency, *n*—probability that a radiation emitted by a radioactive source will be registered by the instrument—also called **counting efficiency**.

detection limit, (*I*) see **minimum detectable value**;

(2) *n*—any of several other quantities defined as “detection limits” by various authorities, including the “method detection limit” (40 CFR Appendix B to Part 136) and the “detection limit” for Safe Drinking Water Act compliance monitoring (40 CFR 141.25).

detector, *n*—device that indicates the presence of a phenomenon or the occurrence of an event without necessarily providing a measured value for it.

dewar, Dewar, *n*—double-walled container with an evacuated space between the walls, often silvered on the innermost surface to prevent heat transfer, used for storing liquefied gases.

disintegrations per minute, dpm, *n*—non-SI unit of activity, equal to 1 min^{-1} —never used with SI prefixes.

electron capture, EC, *n*—mode of radioactive decay in which the nucleus captures an orbital electron, causing the atomic number to decrease by one while the mass number remains unchanged—considered to be a type of beta decay although no beta particle is emitted.

emanation, *n*—release of a gas from a matrix; for example, emanation of ^{222}Rn from soil, water, or other matrix.

enriched uranium, EU, *n*—uranium in which the isotopic abundance of ^{235}U is greater than its natural abundance (cf. **depleted uranium**).

equilibrium, *n*—state of a system in which positive and negative rates of change are balanced so that the overall rate of change is approximately zero (see also **radioactive equilibrium**).

error (of measurement), *n*—difference between the result of a measurement and the true value of the measurand.

DISCUSSION—*Error of measurement* should not be confused with *uncertainty of measurement*. The error of a measurement is generally unknown because the true value is unknown.

escape peak, *n*—peak in a gamma-ray spectrum produced when incident gamma-rays of a particular energy interact with the detector and produce other photons, one or more of which escape from the detector without depositing their energy.

expanded counting uncertainty, *n*—product of the standard counting uncertainty and a coverage factor.

expanded uncertainty, U, *n*—quantity defining an interval about the result of a measurement that may be expected to encompass a large fraction of the distribution of values that could reasonably be attributed to the measurand.

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DISCUSSION—The expanded uncertainty is obtained by multiplying the standard uncertainty of the result by a *coverage factor*.

fossil water, *n*—groundwater that has remained sealed in an aquifer for a long period of time, typically thousands of years or more.

full-energy peak, FEP, *n*—peak in a gamma-ray spectrum produced by those incident photons of a particular energy that deposit all of their energy in the detector.

full width at half maximum, FWHM, *n*—width of a spectral peak at half its height above the baseline—often used as a measure of resolution in spectrometry.

full width at tenth maximum, FWTM, *n*—width of a spectral peak at one-tenth its height above the baseline.

gamma-ray, *n*—photon emitted from a nucleus during certain types of radioactive decay, or produced by annihilation of a particle and its antiparticle.

gamma-ray spectrometry, gamma spectrometry, *n*—measurement of components of a sample or system based on analysis of gamma-ray spectra.

DISCUSSION—In titles and summaries, the full name *gamma-ray spectrometry* is preferred. In other contexts either name is often acceptable.

gas-flow proportional counter, GFPC, *n*—gas proportional counter in which gas flows continuously through the ionization chamber.

gas proportional counter, GPC, *n*—radiation counter based on an ionization chamber where the voltage applied to the chamber electrodes is such that the amplitude of each pulse is proportional to the number of ion pairs generated by an incident radiation.

Gaussian, (1) *adj*—normally distributed;
(2) *adj*—shaped like the graph of the probability density function for a normal distribution (a “bell curve”).

geometry, *n*—geometry.

geometry factor, *n*—mean value of the solid angle subtended by the sensitive portion of a radiation detector at all points of a radioactive source, divided by 4π .

gravimetric, *n*—relating to measurement of or by either mass or weight.

gross, (1) *adj*—before subtraction of background, tare, or other corrections (as in gross count rate)—cf. **net**;
(2) *adj*—lacking detailed information (as in gross alpha activity).

gross alpha activity, *n*—mean rate of alpha decay in a quantity of material.

gross beta activity, *n*—mean rate of beta decay in a quantity of material.

ground state, *n*—minimum-energy state of an atom, molecule, or nucleus.

half-life, radioactive half-life, $T_{1/2}$ [T], *n*—property of a radionuclide, equal to the median lifetime of an atom of that radionuclide, or the time required for, on average, half of any given amount of the radionuclide to decay.

HPGe, *adj*—using or composed of high-purity germanium.

DISCUSSION—High-purity germanium at cryogenic temperatures is a semiconductor that can be used as the principal component of the detector in a high-resolution gamma-ray spectrometry system.

infinite thickness, *n*—thickness of a radioactive source equal to the effective maximum range of a specified particle in that source.

ingrowth, *n*—production of a nuclide by the decay of one or more of its ancestors.

ingrowth factor, *n*—amount of a nuclide expected to be present because of ingrowth from an ancestor, divided by the amount of the ancestor initially present.

DISCUSSION—The value of the ingrowth factor depends on whether the amounts are expressed as activities or numbers of atoms.

instrument check source, ICS, *n*—a radioactive source, not necessarily traceable to a national standards body, that is

used to confirm the continuing satisfactory operation of an instrument. **D7282**

instrument contamination check, ICC, *n*—a measurement to determine if a detector is contaminated with radioactivity. **D7282**

intensity, *n*—probability of emission of a given radiation during the decay of one atom of a given radionuclide—sometimes called abundance.

internal conversion, *n*—mode of radioactive decay in which an excited nucleus imparts its excitation energy to an orbital electron, causing it to be ejected from the atom.

ionization chamber, *n*—device that detects radiation by collecting ion pairs produced when incident radiation ionizes gas in a chamber.

DISCUSSION—The chamber contains electrodes to which a voltage is applied, causing the ion pairs to migrate to the electrodes. Sufficiently high voltages increase the ionization in a process called gas amplification, which strengthens the electrical signal generated by an incident radiation.

ionizing radiation, *n*—radiation with sufficient energy to cause a physical change in an atom making it electrically charged.

DISCUSSION—Four types of ionizing radiation are commonly encountered: alpha radiation, beta radiation, gamma radiation, and neutron radiation.

isomeric transition, IT, *n*—spontaneous transition of a nucleus to a different isomeric state, by either gamma-ray emission or internal conversion.

isotopic abundance, *n*—relative abundance of atoms of a particular isotope in a mixture, expressed as a fraction of the total number of atoms of the element.

DISCUSSION—The term *isotopic abundance* is often used to mean the *natural isotopic abundance*, or the relative abundance of the isotope as the element occurs naturally on Earth.

isotopic tracer, *n*—a unique isotope, either a radioisotope or an enriched uncommon isotope, of the same element as the substance being traced.

DISCUSSION—In radiochemistry, a tracer is usually radioactive and is measured by radioassay to determine the *chemical yield* for one or more analytes.

linear attenuation coefficient—see **attenuation coefficient**.

liquid scintillation cocktail, *n*—mixture of chemicals including a scintillator designed to be mixed with a portion of sample in a vial before the vial is assayed for radiation using a liquid scintillation counter.

liquid scintillation counter, LSC, *n*—specialized instrument used for liquid scintillation counting.

liquid scintillation counting, *n*—scintillation counting in which a portion of the sample is combined with the scintillator in a liquid mixture.

live time, *n*—total amount of time during a radiation counting measurement when the radiation counter is not processing

events and therefore is able to process new events; real time minus total dead time.

luminescence, *n*—emission of light from a material when its atoms have been excited by means other than raising its temperature.

Marinelli beaker, *n*—*in gamma-ray spectrometry*, a type of source container having an overall cylindrical shape with an inverted well at the bottom designed to fit over the detector, intended to improve the detection efficiency by placing a large portion of the source near the detector; named after its original designer L.D. Marinelli—sometimes called a *re-entrant* beaker.

mass attenuation coefficient, μ_m [$L^2 M^{-1}$], *n*—quotient of the linear attenuation coefficient of a material and its mass density.

massic, *adj*—in proportion to mass.

DISCUSSION—The adjective *massic*, when applied to the name of a measurable quantity, indicates the quotient of that quantity and its associated mass, as in *massic activity*.

massic activity, *a* [$M^{-1} T^{-1}$], *n*—quotient of the activity of a quantity of material and its mass.

metastable state, *n*—energy state of a nucleus that is higher than the ground state for that atomic number and mass number and which may persist for a measurable period of time.

metrology, *n*—science of measurement.

minimum detectable value, *n*—estimate of the smallest true value of an analyte (or other measurand) that ensures a specified high probability of detection.

DISCUSSION—Examples include the minimum detectable activity (MDA) and the minimum detectable concentration (MDC).

DISCUSSION—A detection criterion must be specified. See **critical value**.

multichannel analyzer, MCA, *n*—digital electronic device for classifying and recording electrical pulses (for example, produced in a radiation detector) according to strength in a sequence of data registers called channels.

multiplet, *n*—a combination of two or more peaks that are so close together in a spectrum that they are partially or completely superimposed.

NaI(Tl), (*I*) *n*—thallium-doped sodium iodide;
(2) *adj*—using or composed of thallium-doped sodium iodide.

DISCUSSION—NaI(Tl) is a crystalline scintillator which can be used as the principal component of the detector in a gamma-ray spectrometry system.

national standards body, *n*—an organization such as the National Institute of Standards and Technology (NIST) that provides standards traceable to BIPM (Bureau International des Poids et Mesures, or in English the International Bureau of Weights and Measures). **D7282, modified**

DISCUSSION—Traceability is accomplished with guidance from ANSI N42.22.

net, *adj*—after subtraction of background, tare, or other corrections (as in net count rate) – cf. **gross** (1).

NORM, *n*—naturally occurring radioactive material.

(nuclear) disintegration, *n*—radioactive decay of an atomic nucleus.

DISCUSSION—The use of *disintegration* to mean radioactive decay is well established; however, it may be a misnomer for some types of radioactive decay such as electron capture, since the nucleus does not “disintegrate” in the usual sense of the word.

nuclear isobars, *n*—nuclides having the same mass number but different atomic numbers and neutron numbers.

nuclear isomers, *n*—nuclides having the same atomic number and mass number but different nuclear energy states.

nuclide, *n*—species of atom characterized by its mass number, atomic number, and nuclear energy state, having a mean lifetime that is long enough to be observable.

P-10, *n*—gas mixture consisting of 90 % argon and 10 % methane, often used in gas proportional counters.

pair production, *n*—production of an electron and positron from a high-energy photon (>1.022 MeV).

photoluminescence, *n*—emission of light from a material when its atoms have been excited by electromagnetic energy.

photomultiplier tube, PMT, *n*—device for detecting light and amplifying the resulting electrical signal using a photocathode and a series of dynodes inside an evacuated tube—used in scintillation counting.

photopeak, *n*—peak in a gamma-ray spectrum produced by incident photons.

planchet, *n*—small disk, usually metal, with or without a raised edge, on which material is deposited for radiation measurement.

plateau, (1) *n*—for certain types of radiation detectors, a plot of the detector’s response versus the bias voltage, so named because the graph typically has a wide, nearly level portion corresponding to the range of voltages at which the detector is most stable;

(2) *n*—the wide, level portion of such a graph.

DISCUSSION—The plot may have more than one level portion.

progeny, *n*—all the decay products of a given radionuclide, considered collectively.

propagation of uncertainty, uncertainty propagation, *n*—mathematical operation of combining the uncertainties and covariances of a set of measurement results to obtain the uncertainty of another value calculated from those result.

quench curve, *n*—plot of detection efficiency versus a quench indicator.

quench, quenching, *n*—any process that decreases the output or transmission of light energy from the scintillator used in a scintillation counting measurement.

quench indicator, quench-indicating parameter, QIP, *n*—in liquid scintillation counting, a quantity that is measured for each source and used to estimate the degree of quenching for that source.

radiation, *n*—emission and propagation of energy in the form of photons or energetic particles; also the photons or particles emitted.

radiation counter, *n*—radiation detector with associated electronics for counting the detected pulses and in some cases for classifying them by type or energy.

radioactive, (1) *adj*—exhibiting radioactivity;
(2) *adj*—containing radionuclides;
(3) *adj*—of or relating to radioactivity.

radioactive decay, *n*—spontaneous transformation of a nuclide into one or more different nuclides, accompanied by the release of radiation—also called *nuclear decay*.

DISCUSSION—Modes of radioactive decay include alpha decay, beta decay (and electron capture), isomeric transition, and spontaneous fission.

radioactive equilibrium, *n*—condition that exists in a quantity of matter when the ratios of the activities of radionuclides in a decay chain have approached limiting values and are no longer changing appreciably (see also **secular equilibrium** and **transient equilibrium**).

DISCUSSION—Radioactive equilibrium may exist for some or all of the radionuclides in the chain.

radioactive source, *n*—quantity of material configured for use, observation, or measurement of the radiation it emits—often called simply a *source*.

DISCUSSION—The material may or may not be radioactive, but it is treated as potentially radioactive.

radioactivity, *n*—property, exhibited by certain nuclides, of undergoing spontaneous nuclear transformations accompanied by the emission of radiation.

radioanalysis, radioassay, *n*—analysis of radiation emitted by a radioactive source; radiation analysis.

radioanalyst, *n*—person who performs radioanalysis.

radioanalytical, *adj*—relating to or involving radioanalysis.

radiochemical, *adj*—of or relating to radiochemistry.

radiochemist, *n*—practitioner of radiochemistry.

radiochemistry, *n*—branch of chemistry that deals with radioactive materials.

radioisotope, *n*—radioactive isotope.

radiological, *adj*—of or relating to radiology.

radiology, (1) *n*—science of radioactive substances and high-energy radiations;

(2) *n*—branch of medicine that deals with diagnostic and therapeutic applications of radiation.

radiometric, *adj*—relating to measurement of or by radiation.

radiometry, *n*—measurement of radiation.

radiometrology, *n*—science of radiation measurement.

radionuclide, *n*—nuclide that exhibits radioactivity.

random summing, *n*—the result of the random emission of radiation by more than one atom, such that the energy from more than one radiation event is absorbed by the detector within the resolving time of the detector.

DISCUSSION—The consequence of this occurrence is that the total energy absorbed by the detector is the sum of all of the absorbed radiation, rather than the energy of the individual radiation emissions. This effect increases in probability with increasing radiation emission rate of the object being measured

range, *n*—distance that a radiation travels through a given material, or the distance traveled before a specified interaction.

real time, *n*—elapsed time between the beginning and end of a radiation counting measurement—also called *clock time*.

recoil, *n*—movement of an atom away from the direction in which radiation is emitted during radioactive decay.

recovery, (1) *n*—for a spiked or well-characterized sample (for example, reference material), the ratio of the result of a measurement to the target value;

(2) *n*—see **chemical yield**.

DISCUSSION—Use of the term recovery as a synonym for chemical yield may cause confusion and should be avoided.

region of interest, ROI, *n*—in spectrometry, a defined range of energies, or of channels in a multichannel analyzer, where certain radiations are expected to be observed.

relative atomic mass, A_r [1], *n*—ratio of the average mass per atom of a given element or nuclide to the atomic mass constant, or the numerical value of the mass expressed in unified atomic mass units.

relative molecular mass, M_r [1], *n*—ratio of the average mass per molecule of a given substance to the atomic mass constant, or the numerical value of the mass expressed in unified atomic mass units.

relative uncertainty, *n*—quotient of the uncertainty of a measurement result and the absolute value of the result—also relative standard uncertainty, relative expanded uncertainty, relative combined standard uncertainty, etc..

resolution, peak resolution, *n*—sharpness of the peaks in a spectrum, often described in terms of the peak width (for example, the FWHM).

resolving time, *n*—the period of time during which a radiation detector is absorbing the energy from a radiation interaction and is therefore unable to detect an additional event (cf. **dead time**).

DISCUSSION—The resolving time is typically microseconds or less in duration.

sample test source, STS, *n*—a sample, sample aliquant, or final product of a chemical or physical process prepared for the purpose of activity determination. **D7282**

scintillation, *n*—photons produced in certain media in response to an interaction with an individual ray or particle of incident radiation.

scintillation counter, *n*—radiation counter, typically including one or more photomultiplier tubes, that operates by counting the scintillations produced when radiation impinges on a scintillator.

scintillator, *n*—material that emits scintillations in response to incident radiation (for example, sodium iodide or zinc sulfide).

secular equilibrium, *n*—radioactive equilibrium where the half-life of the parent radionuclide is much longer than the half-life of the decay product, and where the activity ratio of the two nuclides approaches its limiting value within a period much shorter than the half-life of the parent (cf. **transient equilibrium**).

self-absorption, *n*—absorption of radiation within the material that contains the radiation-emitting atoms.

self-attenuation, *n*—attenuation of radiation by the material that contains the radiation-emitting atoms.

Si(Li), (1) *n*—lithium-drifted silicon;

(2) *adj*—using or composed of lithium-drifted silicon.

specific—see **massic**.

specific activity—see **massic activity**.

DISCUSSION—The term specific activity is often used to mean the massic activity of a pure substance, such as a radionuclide, element, or compound.

spectrometer, *n*—device for measuring spectra (for example, radiation spectra).

spectrometry, *n*—measurement of radioactive, chemical, or other components of a sample or system based on analysis of spectra (e.g., alpha-particle spectrometry, gamma-ray spectrometry, mass spectrometry).

spectroscopy, *n*—qualitative or quantitative analysis of spectra.

DISCUSSION—Many speakers use the terms *spectrometry* and *spectroscopy* interchangeably; however, only *spectrometry* implies measurement of an analyte.

spectrum, *n*—array of observed quantities or intensities of a physical phenomenon (for example, photons or particles) arranged in order of the magnitude of a common physical property such as energy or mass.

spillover, *n*—phenomenon in radiation counting where particles of a particular type or energy distribution are recorded in channels of the multichannel analyzer beyond their designated region of interest.

spontaneous fission, SF, *n*—mode of radioactive decay in which a nucleus splits into two or more relatively large nuclei; spontaneous nuclear fission.

stable, (1) *adj*—(nuclides) not exhibiting radioactivity;
(2) *adj*—(measuring instruments) not exhibiting large or rapid changes in metrological characteristics.

standard counting uncertainty, *n*—counting uncertainty of the result of a radiochemical analysis expressed as a standard deviation.

standard uncertainty, *u*, *n*—uncertainty of the result of a measurement expressed as a standard deviation. **GUM**

summing, *n*—absorption by a radiation detector of the combined energies from two or more coincident radiations, which appear as if they were a single radiation of higher energy (see also **cascade summing** and **random summing**).

DISCUSSION—The term *summing* in refers to the increase in the count rate observed at the combined energy of the coincident radiations. The term *summing out* refers to the reduction in the count rates observed at the energies of the individual radiations.

sum peak, *n*—peak in a gamma-ray spectrum produced by the summing of two or more photon energies.

supported, *adj*—being replenished by ingrowth.

tailing, *n*—broadening of the lower portion of a spectral peak on one or both sides, resulting in a non-ideal peak shape.

DISCUSSION—The broadened portion of the peak on either side is called a *tail*. In a radiation spectrum, the tail may be a *low-energy tail* or a *high-energy tail*.

total dead time, *n*—the cumulative dead time for a measurement, usually expressed as a percentage or fraction of the real time (see also **dead time**).

traceability, *n*—for a measurement result, the property of being related to a reference standard, generally a national or international standard, through a documented unbroken chain of measurements, each having a stated uncertainty that contributes to the total uncertainty of the final result.

transient equilibrium, *n*—radioactive equilibrium where the half-life of the parent radionuclide is longer but not very much longer than the half-life of the decay product, and where the time required for the activity ratio of the two nuclides to approach its limiting value is not much shorter than the half-life of the parent (cf. **secular equilibrium**).

DISCUSSION—Examples include ^{95}Zr and its daughter ^{95}Nb , or ^{140}Ba and its daughter ^{140}La .

uncertainty propagation—see **propagation of uncertainty**.

uncertainty (of measurement), *n*—parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand. **GUM**

unsupported, *adj*—not being replenished by ingrowth.

volumetric, *adj*—relating to measurement of or by volume.

volumic, *adj*—in proportion to volume.

DISCUSSION—The adjective *volumic*, when applied to the name of a measurable quantity, indicates the quotient of that quantity and its associated volume, as in *volumic activity*.

volumic activity, c_A [$\text{L}^{-3} \text{T}^{-1}$], *n*—quotient of the activity of a quantity of material and its volume—also called *activity concentration*.

weight, (1) *n*—product of the mass of a body and the local acceleration of free fall;

(2) *n*—in nonscientific usage, the mass of a body.

working calibration source, WCS, *n*—a calibration source, including those diluted or prepared by chemical procedure for the purpose of calibrating an instrument. **D7282**

yield, *n*—see **chemical yield**.

5. Symbols, Abbreviations, and Acronyms

a—massic activity

A_r —relative atomic mass

C_A —volumic activity

cpm—counts per minute

CS—calibration source

dpm—disintegrations per minute

DU—depleted uranium

EU—enriched uranium

EC—electron capture

FEP—full-energy peak

FWHM—full width at half maximum

FWTM—full width at tenth maximum

GFPC—gas-flow proportional counter

GPC—gas proportional counter

GUM—*Guide to the Expression of Uncertainty in Measurement*

HPGe—high-purity germanium

IC—internal conversion

ICC—instrument contamination check

ICS—instrument check source

IT—isomeric transition

k—coverage factor

LSC—liquid scintillation counter

MCA—multichannel analyzer

MDA—minimum detectable activity

M_r —relative molecular mass

NIST—National Institute of Standards and Technology

NORM—naturally occurring radioactive material

NRC—Nuclear Regulatory Commission

PMT—photomultiplier tube

QIP—quench-indicating parameter

ROI—region of interest

SF—spontaneous fission

SI—International System of Units (Système internationale d'unités)

Si(Li)—lithium-drifted silicon

STS—sample test source

$T_{1/2}$ —half-life

U —expanded uncertainty

$u(x)$ —standard uncertainty of x

$u_c(y)$ —combined standard uncertainty of y

WCS—working calibration source

λ —decay constant

μ or μ_1 —linear attenuation coefficient

μ_m —mass attenuation coefficient

6. Keywords

6.1 terminology; radiation; radioactivity; radiochemistry; radioanalysis

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