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Standard Terminology for Radiochemical Analyses[1]

This standard is issued under the fixed designation D7902; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

ε[1] NOTE—Editorial changes were made throughout in January 2015.

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

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

4π 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, (*1*) *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**.

[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://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.

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, ^{238}U 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, (*1*) *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 ^{4}He 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.

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

~~Ĉerenkov~~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 ^{131}I.

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, (*1*) *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.

DISCUSSION—

The curie may be used with SI prefixes.

DISCUSSION—

The curie is such a large unit that the picocurie (symbol pCi) is more commonly used in the analysis of environmental samples.

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

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, (*1*) *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, ~~λ/T~~λ [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.~~λ*N*.

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}~~235U~~U is less than its natural abundance (cf. **enriched uranium**).

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

detect, (*1*) *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**.