Definition of Terms and Explanatory Notes

Official Methods[SM]

(*1*) *Official Methods*[SM] are designated First Action or Final Action, and, in a few cases, Procedures. A First Action method has undergone rigorous scientific scrutiny, has been recommended by the appropriate body, and has been adopted as a First Action *Official Method*[SM] by an AOAC expert review panel (ERP; 2011 to present) or methods committee (prior to 2011). A method may be adopted as Final Action 2 years after it has been adopted First Action, and after it has been recommended by the appropriate ERP, and voted on by the Official Methods Board (OMB).

Sampling, test sample preparation protocol, or other type of instructions for which an interlaboratory collaborative study is impractical may be adopted, as above, as a Procedure.

All methods in this book—First Action, Final Action, or Procedure—are *Official Methods of Analysis*[SM] of AOAC INTERNATIONAL.

Reagents

(*2*) Term "H_2O" means distilled or deionized water, except where otherwise specified, and except where the water does not mix with the determination, as in "H_2O bath."

(*3*) Term "alcohol" means 95% ethanol by volume. Alcohol of strength x% may be prepared by diluting x mL 95% alcohol to 95 mL with H_2O. Absolute alcohol is 99.5% by volume. Formulas of specially denatured alcohols (SDA) used as reagents in the United States under 27CFR21 are as follows:

SDA No.	100	Parts alcohol plus
3-A	5	Parts methanol
3-C	5	Isopropyl alcohol
30	10	Parts methanol

"Reagent" alcohol is 95 parts SDA 3-A plus 5 parts isopropanol.

(*4*) Term "ether" means ethyl ether, peroxide free by the following test: To 420 mL ether in separator, add 9.0 mL 1% NH_4VO_3 in H_2SO_4 (1 + 16). Shake 3 min and let separate. Drain lower layer into 25 mL glass-stoppered graduate, dilute to 10 mL with H_2SO_4 (1 + 16), and mix. Any orange color should not exceed that produced by 0.30 mg H_2O_2 (1 mL of solution prepared by diluting 1 mL 30% H_2O_2 to 100 mL with H_2O) and 9.0 mL 1% NH_4VO_3 in H_2SO_4 (1 + 16). Peroxides may be eliminated by passing ≤700 mL ether through 10 cm column of Woelm basic alumina in 22 mm id tube.

(*5*) The following listed reagents, unless otherwise specified, have approximate strength stated and conform in purity with Recommended Specifications for Analytical Reagent Chemicals of the American Chemical Society:

	Assay
Sulfuric acid	95.0–98.0% H_2SO_4
Hydrochloric acid	36.5–38.0% HCl
Nitric acid	68.0–70.0% HNO_3
Fuming nitric acid	≥90% HNO_3
Acetic acid	≥99.7% CH_3COOH
Hydrobromic acid	47.0–49.0% HBr
Ammonium hydroxide	28–30% NH3
Phosphoric acid	≥85% H_3PO_4

Where no indication of dilution is given, reagent concentration is the concentration given above.

(*6*) All other reagents and test solutions, unless otherwise described in the text, are automatically reagent grade and conform to requirements of the American Chemical Society. Where such specifications have not been prepared, use highest grade reagent. When anhydrous salt is intended, it is so stated; otherwise the hydrated product is meant.

(*7*) Unless otherwise specified, phenolphthalein used as indicator is 1% alcohol solution; methyl orange is 0.1% aqueous solution; methyl red is 0.1% alcohol solution.

(*8*) Directions for standardizing reagents are given in *Appendix A, Standard Solutions and Certified Reference Materials*.

(*9*) Unusual reagents not mentioned in reagent sections or cross referenced, other than common reagents normally found in laboratories, are italicized the first time they occur in a method.

(*10*) Commercially prepared reagent solutions must be checked for applicability to a specific method. They may contain undeclared buffers, preservatives, chelating agents, etc.

(*11*) In expressions (1 + 2), (5 + 4), etc., used in connection with name of reagent, the first numeral indicates the volume of reagent used and the second numeral indicates volume of H_2O. For example, HCl (1 + 2) means reagent prepared by mixing one volume HCl with two volumes H_2O. When one of the reagents is a solid, expression means part by weight. The first numeral represents the solid reagent; the second numeral H_2O. Solutions for which the solvent is not specified are aqueous solutions.

(*12*) In making up solutions of definite percentage, it is understood that x g substance is dissolved in H_2O and diluted to 100 mL. Although not theoretically correct, this convention will not result in any appreciable error in any methods given in this book.

(*13*) Chromic acid cleaning solution is prepared by (*1*) adding 1 L H_2SO_4 to approximately 35 mL saturated aqueous $Na_2Cr_2O_7$ solution; or (*2*) adding 2220 mL H_2SO_4 to approximately 25 mL saturated aqueous CrO_3 solution (170 g/100 mL). Reagents may be technical high grade. Use only after first cleaning by other means (e.g., detergent) and draining. Mixture is expensive and hazardous. Use repeatedly until it is

diluted or has a greenish tinge. Discard carefully with copious amounts of H_2O. Refer to *Appendix B, Laboratory Safety* chapter.

(*14*) All calculations are based on international atomic weights.

Apparatus

(*15*) Burets, volumetric flasks, and pipets conform to the following U.S. Federal specifications (available from General Services Administration, Specification Section, L'Enfant Plaza, Ste 8100, Washington Navy Yard, Bldg 197, Washington, DC 20407, USA):

Buret	A-A-51248	May 19, 1965
Flask, volumetric	A-A-51360	February 7, 1977
Pipet, volumetric	A-A-53890	February 24, 1978

See also Appendix V, "Testing of Glass Volumetric Apparatus," in the National Institute of Standards and Technology (NIST) Specification Publication 260-54, "Certification and Use of Acidic Potassium Dichromate Solutions as an Ultraviolet Absorbance Standard SRM 935" (available from NIST, Office of Standard Reference Materials, B316 Chemicals, Gaithersburg, MD 20899, USA).

(*16*) Standard taper glass joints may be used instead of stoppers where the latter are specified or implied for connecting glass apparatus.

(*17*) Sieve designations, unless otherwise specified, are those described in U.S. Federal Specification RR-S-366e, November 9, 1973 (available from General Services Administration). Designation "100 mesh" (or other number) powder (material, etc.) means material ground to pass through standard sieve No. 100 (or other number). Corresponding international standard and U.S. standard sieves are given in Table 1.

(*18*) Term "paper" means filter paper, unless otherwise specified.

(*19*) Term "high-speed blender" designates mixer with four canted, sharp-edge, stainless steel blades rotating at the bottom of 4-lobe jar at 10 000–12 000 rpm, or with equivalent shearing action. Suspended solids are reduced to fine pulp by action of blades and by lobular container, which swirls suspended solids into blades. Waring Blender, or equivalent, meets these requirements.

(*20*) "Flat-end rod" is glass rod with one end flattened by heating to softening in flame and pressing vertically on flat surface to form circular disk with flat bottom at end.

(*21*) Designation and pore diameter range of fritted glassware are: extra coarse, 170–220 μm; coarse, 40–60; medium, 10–15; fine, 4–5.5; Jena designations and pore diameter are: (*1*) 110 μm; (*2*) 45; (*3*) 25; (*4*) 8.

(*22*) Unless otherwise indicated, temperatures are expressed in degrees Celsius (Centigrade).

Sample

(*23*) Terminology and usage for items and operations colloquially designated with the term "sample": Newly adopted methods will avoid the confusing usage of the term "sample" for anything the analyst is working with. The nomenclature recommended by the International Union of Pure and Applied Chemistry (IUPAC), *Pure & Appl. Chem.* **62,** 1193(1990), for analytical chemistry, based upon the International Organization for Standardization (ISO) recommendations, will be utilized. The critical definitions are:

Table 1. Nominal dimensions of standard test sieves (USA standard series)

Sieve designation		Nominal sieve opening, in.	Nominal wire diameter, mm
International standard[a] (ISO)	USA standard		
12.5 mm[b]	1/2 in.[b]	0.500	2.80
11.2 mm	7/16 in.	0.438	2.50
9.5 mm	3/8 in.	0.375	2.24
8.0 mm	5/16 in.	0.312	2.00
6.7 mm	0.265 in.	0.265	1.80
6.3 mm	1/4 in.[b]	0.250	1.80
5.6 mm	No. 3	0.223	1.60
4.75 mm	No. 4	0.187	1.60
4.00 mm	No. 5	0.157	1.25
3.35 mm	No. 6	0.132	1.00
2.80 mm	No. 7	0.111	0.90
2.36 mm	No. 8	0.0937	0.80
2.00 mm	No. 10	0.0787	0.71
1.70 mm	No. 12	0.0661	0.63
1.40 mm	No. 14	0.0555	0.56
1.18 mm	No. 16	0.0469	0.45
1.00 mm	No. 18	0.0394	0.40
850 μm[c]	No. 20	0.0331	0.355
710 μm	No. 25	0.0278	0.315
600 μm	No. 30	0.0234	0.280
500 μm	No. 35	0.0197	0.224
425 μm	No. 40	0.0165	0.200
355 μm	No. 45	0.0139	0.180
300 μm	No. 50	0.0117	0.160
250 μm	No. 60	0.0098	0.125
212 μm	No. 70	0.0083	0.100
180 μm	No. 80	0.0070	0.090
150 μm	No. 100	0.0059	0.080
125 μm	No. 120	0.0049	0.063
106 μm	No. 140	0.0041	0.056
90 μm	No. 170	0.0035	0.045
75 μm	No. 200	0.0029	0.040
63 μm	No. 230	0.0025	
53 μm	No. 270	0.0021	

[a] These standard designations correspond to the values for test sieve apertures recommended by the International Organization for Standardization, Geneva, Switzerland.
[b] These sieves are not in the standard series but they have been included because they are in common usage.
[c] 1000 μm = 1 mm.

A *laboratory sample* is the material sent to or received by the laboratory. The laboratory reduces the laboratory sample in size and fineness to a *test sample* (or *analytical sample* if only chemical or microbiological analysis is involved). A *test* (or *analytical*) portion

is removed from the test sample for analysis. Once a test portion is measured, by mass or volume, the term "sample" is no longer appropriate. Use "test" or "unknown" as the modifier, e.g., "test solution," not "sample solution."

The operation often called "preparation of sample" applies to the reduction of the laboratory sample to the test sample, and not to the usual analytical steps of solution, separation, purification, or isolation of the analyte.

The term "sample" will be used solely in the statistical sense as a small portion representing a larger quantity, such as a lot or a batch, where the potential exists for a "sampling error" due to the heterogeneity of the parent population. Most samples are removed from a static population, such as a pile of fertilizer, a stack of cases, or a group of containers. In a dynamic situation, however, where the population changes with time as a flowing river, circulating blood, or a moving conveyor belt, the small portion removed should be called a *"specimen"* In these cases, the phenomenon under study and the sampling error are confounded in such a way that they cannot be separated.

See Figure 1 [International Union of Pure and Applied Chemistry, "Nomenclature for Sampling in Analytical Chemistry," *Pure & Appl. Chem.* **62**, 1193(1990)].

Standard Operations

(*24*) Operations specified as "wash (rinse, extract, etc.) with two (three, four, etc.) 10 mL (or other volumes) portions H_2O (or other solvent)" mean that the operation is to be performed with indicated volume of solvent and repeated with same volume of solvent until number of portions required have been used.

(*25*) Definitions of terms used in methods involving spectrophotometry are those given in *JAOAC* **37**, 54(1954). Most important principles and definitions are:

(**a**) More accurate instrument may be substituted for less accurate instrument (e.g., spectrophotometer may replace colorimeter) where latter is specified in method. Wavelength specified in method is understood to be that of maximum absorbance (*A*), unless no peak is present.

(**b**) *Absorbance(s)* (*A*): Negative logarithm to base 10 of the ratio of transmittance (*T*) of test solution to that of reference or standard material. Other names that have been used for quantity represented by this term are optical density, extinction, and absorbency.

(**c**) *Absorptivity(ies)* (*a*): Absorbance per unit concentration and cell length.

$$a = A / bc$$

where *b* is in cm and *c* = g/L, or *a* = (*A/bc*) × 1000, if *c* is mg/L. Other names that have been used for this or related quantities are extinction coefficient, specific absorption, absorbance index, and $E_{1cm}^{1\%}$.

(**d**) *Transmittance(s)* (*T*): Ratio of radiant power transmitted by the test solution to radiant power incident on solution, when both are measured at same spectral position and with same slit width. Beam is understood to be parallel radiation and incident at right angles to plane parallel surface of test material. If test material is solution, solute transmittance is quantity usually desired and is calculated directly as ratio of transmittance of solution in cell to transmittance of solvent in an equal cell. Other names that have been used for this quantity are transmittancy and transmission.

(**e**) *Standardization:* Spectrophotometer may be checked for accuracy of wavelength scale by referring to Hg lines: 239.94, 248, 253.65, 265.3, 280.4, 302.25, 313.16, 334.15, 365.43, 404.66, 435.83, 546.07, 578.0, and 1014.0 nm. To check consistency of absorbance scale, prepare solution of 0.0400 g K_2CrO_4/L 0.05 M KOH and determine absorbance at following wavelengths in 1 cm cell: 230 nm, 0.171; 275 nm, 0.757; 313.2 nm, 0.043; 375 nm, 0.991; 400 nm, 0.396. *See NIST Spec. Pub. 378,* "Accuracy in Spectrophotometry and Luminescence Measurements," 1973 (available from NIST, Office of Standard Reference Materials, B316, Chemistry, Gaithersburg, MD 20899, USA).

(*26*) Least square treatment of data and calculation of regression lines. This technique finds the best fitting straight line for set of data such as standard curve. It calculates that straight line for which the sum of squares of vertical deviations (usually *A*) of observations from the line is smaller than corresponding sum of squares of deviation from any other line. Equation of straight line is:

$$Y = a + bX$$

where *a* is intercept at *Y* axis (*X* = 0), and *b* is slope of line.

Least square estimates of constants are:

$$b = \frac{\sum (X_i Y_i) - \left[\left(\sum X_i \sum Y_i\right)/n\right]}{\sum X_i^2 - \left[\left(\sum X_i\right)^2/n\right]}$$

$$a = \bar{Y} - b\bar{X}$$

where Σ = "sum of" the *n* individual values of indicated operation, and $\bar{X}$ and $\bar{Y}$ are the averages of the *X* and *Y* points.

Example: To find "best" straight line relating A(Y) to concentration (X):

Observation No. (*i*)	Concentration X_i	Absorbance Y_i	X_i^2	X_iY_i
1	80	1.270	6400	101.6
2	60	1.000	3600	60.0
3	40	0.700	1600	28.0
4	30	0.550	900	16.5
5	20	0.250	400	5.0
6	10	0.100	100	1.0
7	0	0.050	0	0.0
Totals:				
n = 7	ΣX_i = 240	ΣY_i = 3.92	ΣX_i^2 = 1300	Σ(X_iY_i) = 212.1

$$\bar{X} = \Sigma X_i / n = 240/7 = 34.29$$

$$\bar{Y} = \Sigma Y_i / n = 3.92/7 = 0.56$$

$$b = \frac{212.1 - \left[(240)(3.92)\right]/7}{13000 - \left[(240)^2/7\right]} = \frac{77.7}{4771} = 0.0163$$

$$a = 0.56 - 0.0163(34.29) = 0.001 \cong 0$$

Best equation is then:

$$Y = 0.00 + 0.0163X$$

SAMPLING OPERATIONS
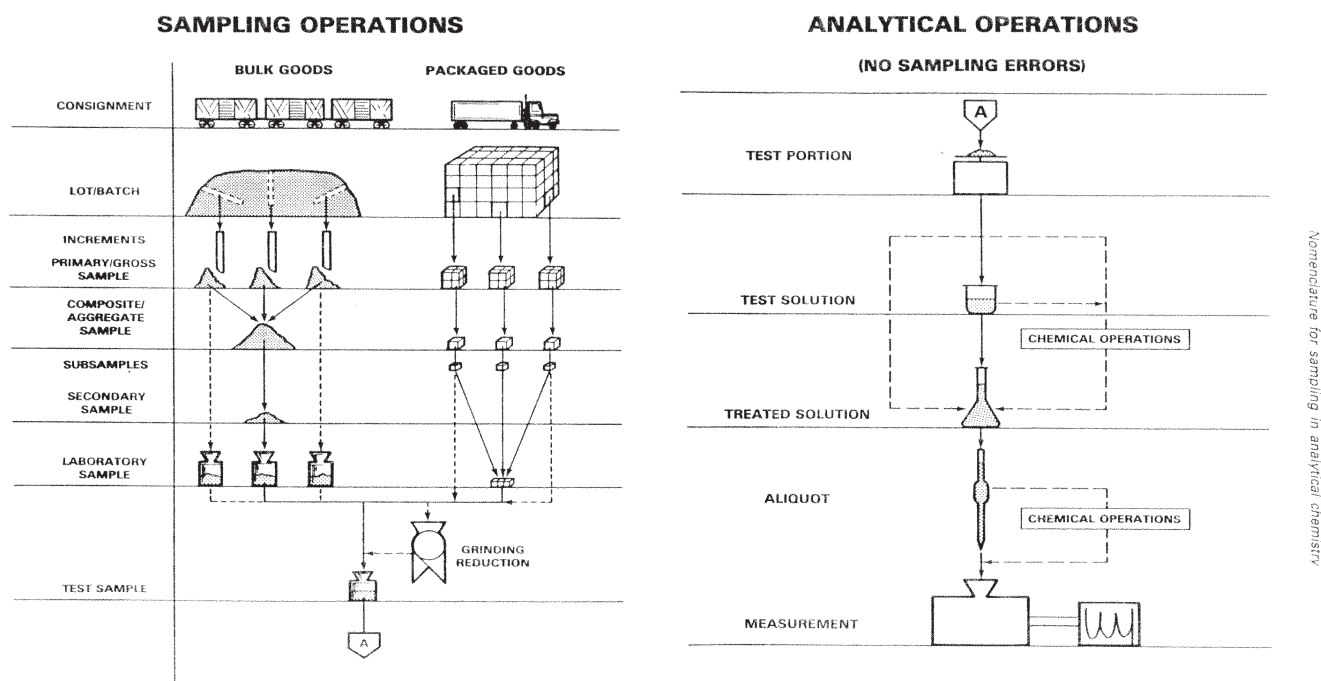
ANALYTICAL OPERATIONS

Figure 1.   The relationships of the operations involved in sampling and analysis. The lower "A" of the sampling operations continues with the upper "A" of the analytical operations.

If for test sample, $A = 0.82$, corresponding concentration (X) would be:

$$X = (Y - 0.00)/0.0163 = 0.82/0.0163 = 50.3$$

Many scientific and statistical calculators are programmed to perform this calculation. It should be noted that the least square fit of a data set should not be the only criterion used in evaluating the validity of a given data set.

High correlation coefficients (e.g., >0.99) do not necessarily indicate linearity. This misinformation has been the subject of several reports from the Analytical Methods Committee of the Royal Society of Chemistry [*Analyst* **113**, 1469–1471(1988); **114**, 753(1989); **119**, 2363–2366(1994)]. Statistically, such a correlation coefficient applies only when both x and y are variables; a standard curve requires that one parameter (concentration) be fixed (known).

When a high correlation is desired between the signal and concentration, use the symbol "r²" for the relationship as calculation by computer spreadsheet programs.

(*27*)   Recovery (R) of analyte from fortified test material by a method of analysis. Fraction of an analyte added to a test sample (fortified test sample) prior to analysis, which is measured (recovered) by the method. When the *same* analytical method is used to analyze both the unfortified and fortified test samples, calculate percent R as follows:

$$R,\% = \frac{C_F - C_U}{C_A} \times 100$$

where C_F = concentration of analyte measured in fortified test sample; C_U = concentration of analyte measured in unfortified test sample; C_A = concentration of analyte *added* to fortified test sample. (*Note: C_A* is a calculated value, not a value measured by the method being used.)

Concentration of added analyte should be no less than concentration of analyte in unfortified test sample. Sum of concentration of added analyte plus analyte present before fortification should be in the same range as analyte concentration sought in actual test samples. Addition of analyte must not cause measuring instrument to exceed linear dynamic range of standard curve. Both fortified and unfortified test samples must be treated identically during analysis to minimize experimental bias.

(*28*) Common safety precautions are given in *Appendix B, Laboratory Safety.*

Results of Interlaboratory Study

(*29*)   Users of methods should consult the report of the collaborative study (reference given with the method) for details as to results of the interlaboratory study.

Editorial Conventions

(*30*)   For simplicity, the abbreviations Cl, H, I, N, and O are used rather than their diatomic forms. The charge may not be indicated with the corresponding ion where no ambiguity will result.

(*31*)   Reagents and apparatus referenced with only a letter, e.g., **(c)**, will be found in the *Reagent* or *Apparatus* section of the method.

(*32*)   To conserve space, many articles and prepositions have been eliminated.

Manufacturers and Suppliers

Many manufacturers and suppliers may be found by a search of the Internet. **The same or equivalent products, instruments, supplies, apparatus, or reagents available from manufacturers and suppliers**

other than those named, or other brands from other sources, may serve equally well if proper validation indicates their use is satisfactory.

Abbreviations

(*33*) The following abbreviations, many of which conform with those of *Chemical Abstracts,* are used. In general, principle governing use of periods after abbreviations is that period is used where final letter of abbreviation is not the same as final letter of word it represents.

Abbreviation	Word
a	Absorptivity(ies)
A	Absorbance(s) throughout (not restricted to formulas; not absorption). *A′* is used for standard; A_0 is used for blank; 3-digit subscript numerals usually denote wavelength in nm
A	Ampere
Å	Angstrom
AA	Atomic absorption
AACC	American Association of Cereal Chemists
ACS	American Chemical Society
ALACC	AOAC Analytical Laboratory Accreditation Criteria Committee
amu	Atomic mass unit
AOAC RI	AOAC Research Institute
AOCS	American Oil Chemists' Society
APHA	American Public Health Association
ASBC	American Society of Brewing Chemists
ASTM	American Society of Testing and Materials
atm.	Atmosphere
AU	Absorbance units
AUFS	Absorbance units full scale
BAM	*Bacteriological Analytical Manual* (U.S. Food and Drug Administration)
Bé	Degree Baumé
bp	Boiling point
Bq	Becquerel
C	Degree Celsius (Centigrade)
ca	About, approximately
Cat. No.	Catalog number
CDC	Centers for Disease Control and Prevention
CFU	Colony-forming unit(s)
Ch.	Chapter
Ci	Curie(s) (= 3.7×10^{10} Bq)
CI	Color index
CIPAC	Collaborative International Pesticide Analytical Council
cm	Centimeter(s)
concn	Concentration
cP	Centipoise
cpm	Counts per minute
CRM	Certified reference material

Abbreviation	Word
*cu in.	Cubic inch(es)
dc	Direct current
DMF	*N,N*-dimethylformamide
DMSO	Dimethyl sulfoxide
EDTA	Ethylenedinitrilotetraacetic acid (or -tetraacetate)
EIA	Enzyme immunoassay
ELISA	Enzyme-linked immunosorbent assay
EPA	U.S. Environmental Protection Agency
ERP	Expert review panel
Exp	Exponential
F	Degrees Fahrenheit [°C = (5/9) × (°F − 32)]
FAO	Food and Agriculture Organization
FDA	U.S. Food and Drug Administration
FEP	Fluorinated ethylene propylene
*fl oz	Fluid ounce (29.54 mL)
fp	Freezing point
FSD	Full scale deflection
*ft	Foot (30.48 cm)
g	Gram(s)
g	Gravity (in centrifuging)
*gal.	Gallon(s) (3.785 L)
gr.	Grain(s) (1 grain = 64.8 mg)
GC	Gas chromatography
h	Hour(s)
HorRat	Horwitz ratio
HPLC	High-performance liquid chromatography
ICC	International Association for Cereal Science and Technology
ICP-MS	Inductively coupled plasma-mass spectrometry
id	Inner diameter
IgG	Immunoglobulin G
*in.	Inch(es) (2.54 cm)
IR	Infrared
ISO	International Organization for Standardization
ISPAM	International Stakeholder Panel on Alternative Methods
kg	Kilogram(s)
kPa	Kilopascal
L	Liter(s)
LC	Liquid chromatography
LPTP	Laboratory Proficiency Testing Program
*lb	Pound(s) (453.6 g)
m	Meter(s); milli—as prefix
m	Molal
M	Molar (as applied to concentration), not molal
mA	Milliampere(s)
mΩ	Megaohm
min	Minutes
min.	Minimum
mg	Milligram(s)

Abbreviation	Word
mL	Milliliter(s)
MLG	*Microbiology Laboratory Guidebook* (U.S. Department of Agriculture)
MLV	Multilaboratory validation
mm	Millimeter(s)
mp	Melting point
MS	Mass spectrometry
MSDS	Material Safety Data Sheet (www.cdc.gov/niosh/ipcs/nicstart.html)
mμ	Millimicron (10^{-6} mm); use nanometer (nm) (10^{-9} m)
mV	Millivolt
MW	Molecular weight (molar mass)
N	Normal (as applied to concentration; in equations, normality of titrating reagent)
N	Newton (10^5 dynes)
n	Refractive index
NF	National Formulary
NFPA	National Food Processors Association
NIST	National Institute of Standards and Technology
ng	Nanogram (10^{-9} g)
nm	Nanometer (10^{-9} m); formerly mμ
No.	Number
OMB	AOAC Official Methods Board
od	Outer diameter
ODS	Octadecylsilane
OMA	*Official Methods of Analysis*^{SM} (an idiom used to refer to program, method status, or compendium of methods)
*oz	Ounce(s) (28.35 g)
p	Pico (10^{-12}) as prefix
Pa	Pascal [1 Newton/m^2; 9.87×10^{-6} atm; 7.5×10^{-3} mm Hg (torr); 1.45×10^{-4} psi]
pCi	Pico Curie(s) = 27.027 Bq
*ppb	Parts per billion (10^{-9})
*ppm	Parts per million (10^{-6})
ppt	Parts per trillion (10^{-12})
*psi	Pounds per square inch (absolute)
*psig	Pounds per square inch gauge (atmospheric pressure = 0)
*pt	Pint(s) (473 mL)
PTM	*Performance Tested Methods*^{SM} (an idiom used to refer to program or method status)
QAC	Quaternary ammonium compound
*qt	Quart(s) 946 mL
R	Reproducibility value (= $2.8 \times s_R$)
r	Repeatability value (= $2.8 \times s_r$)
®	Trademark name (registered)
R_f	Distance spot moved/distance solvent moved, TLC
rpm	Revolutions per minute
s	Second(s)
SDF	Special denatured formula (applied to alcohol)
SLV	Single-laboratory validation
SMPR®	*Standard Method Performance Requirement*

Abbreviation	Word
SPADA	Stakeholder Panel on Agent Detection Assays
SPDS	Stakeholder Panel on Dietary Supplements
SPIFAN	Stakeholder Panel on Infant Formula and Adult Nutritionals
SPSFAM	Stakeholder Panel on Strategic Foods Analytical Methods
sq	Square
SRM	Standard Reference Material (CRM of National Institute of Standards and Technology)
T	Transmittance
TLC	Thin-layer chromatography
™	Trademark
ton	= 907 kg
U	Unit
USDA	United States Department of Agriculture
USP	United States Pharmacopeia
UV	Ultra violet
V	Volt(s)
v/v	Volume per volume
WG	Working group
WHO	World Health Organization
w/v	Weight per volume
$\bar{x}$	Mean
X^2	Chi square
β	Beta
λ	Lambda
γ	Gamma
μ	Micro
μc	Micro coulomb
μm	Micron (0.001 mm); use micrometer (10^{-6} m)
μg	Microgram(s) (10^{-6} g)
μL	Microliter(s) (10^{-6} L)
Δ	Difference [e.g., $\Delta A = (A - A')$]
Ω	Ohm
∑	Sum
*′	Foot (feet) (1′ = 30.48 cm)
*″	Inch(es) (1″ = 2.54 cm)
/	Per
%	Percent (parts per hundred); percentage
% Rec.	Percent recovery
‰	Parts per thousand
>	More than; greater than; above; exceeds (use with numbers only)
<	Less than; under; below (use with numbers only)
≤	Equal to or less than
≥	Equal to or greater than

* = Not official SI units; no longer recommended for use in AOAC INTERNATIONAL.

Conversion table for concentration units

	Parts/thousand	Parts/million	Parts/billion	Parts/trillion
%	10	10000	10000000	10000000000
Parts per thousand	1	1000	1000000	1000000000
Parts per million	0.001	1	1000	1000000
Parts per billion	0.000001	0.001	1	1000
Parts per trillion	0.000000001	0.000001	0.001	1

Use: One unit in left column equals the number of units in columns 2–5. Example: 5% = 50000 parts per million; 2 ppm = 2000 ppb; 5 ppb = 0.005 ppm.

Note: These units are no longer recommended because United States and international usage differ. Use scientific nomenclature 10000 = E + 4; 0.000 1 = E − 4.