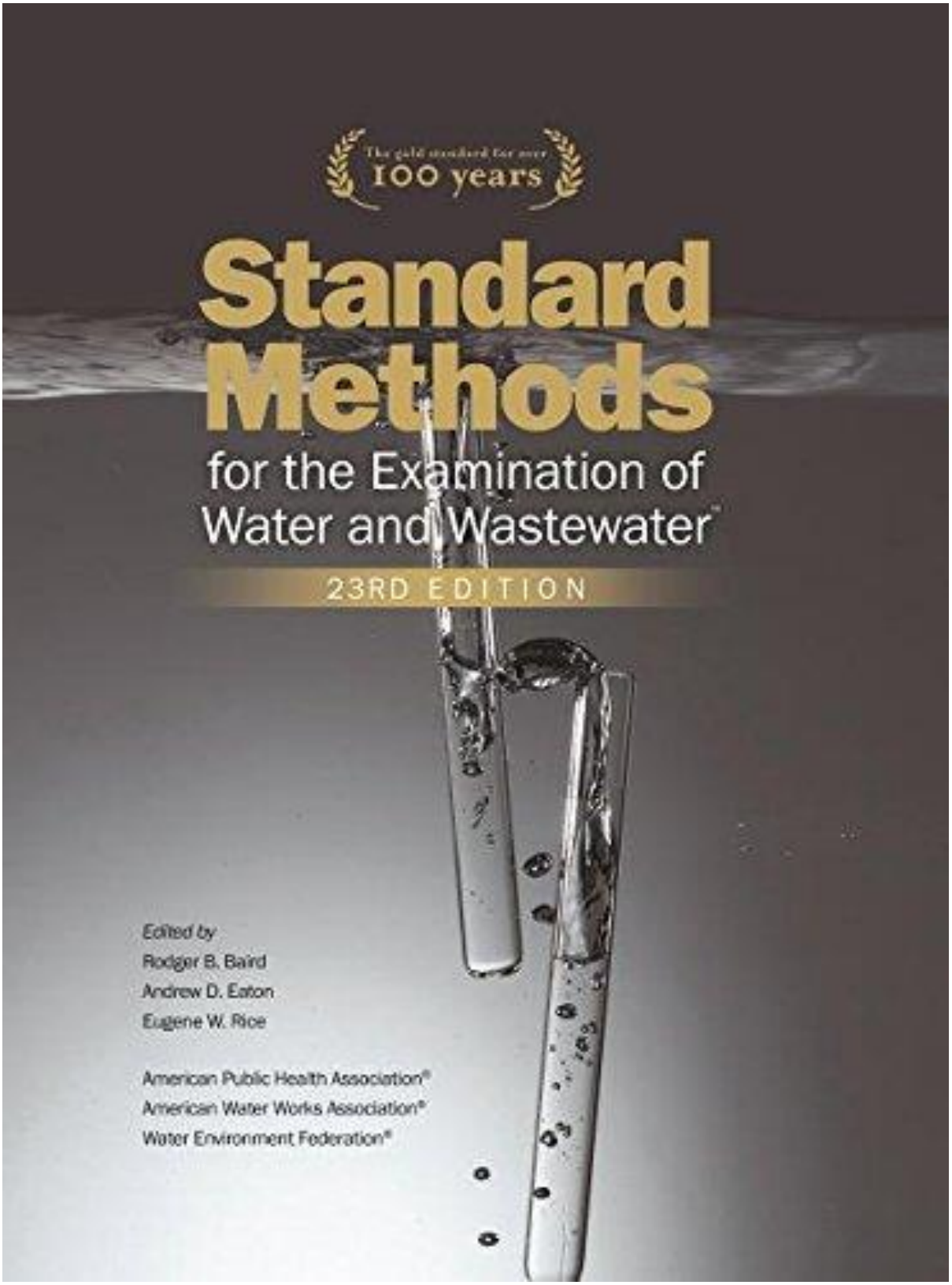

Standard Methods for the Examination of Water and Wastewater, 23rd Edition

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Item Details:

Analysts, researchers, and regulators have relied on this peer-reviewed publication since 1905. The trusted source of accurate, proven methodology for analyzing natural waters, water supplies, and wastewaters. The 23rd edition of *Standard Methods for the Examination of Water and Wastewater*® contains over 400 laboratory methods for the analysis of

- Dissolved Solids
- Metals
- Free and Total Chlorine
- Odor, Taste, and Flavor Profile Analysis
- Disinfection By-products
- Radionuclides
- Total Organic Carbon
- Total and Fecal Coliform

Laboratories worldwide rely on this comprehensive reference as the trusted source of accurate, proven methodology for analysis of water, water supplies, and wastewater. It is the essential resource for water analysis professionals.

The methods in the 23rd edition (as in previous editions) are believed to be the best available, generally accepted procedures for analyzing water, wastewater, and related materials. They represent the recommendations of specialists, ratified by a large number of analysts and others of more general expertise, and as such are truly consensus standards, offering a valid and recognized basis for control and evaluation. All methods are dated to identify which ones changed significantly between editions.

New in the 23rd edition

- Over 80 revised methods and 5 new methods added
- Extensive revisions to Microbiological Examination (Part 9000)
- New drinking water method to test for pharmaceuticals and personal care products
- New, more realistic, visuals to help identify aquatic organisms
- Revisions to Solids, Cyanide, Nitrate, Dissolved Oxygen, and Biochemical Oxygen Demand

23rd Edition Now Available Online

November 27, 2017

This notice is to inform *Standard Methods* online users that all sections from the 23rd Edition are now available online. Below is a list of sections that underwent substantive changes between editions:

Section	Title
1020	Quality Assurance
1040	Method Development and Evaluation
2020	Quality Assurance/Quality Control
2150C	Total Intensity of Odor (New)
2330	Calcium Carbonate Saturation
2540	Solids
3020	Quality Assurance/Quality Control
4020	Quality Assurance/Quality Control
4500-CN^-	Cyanide
4500-NO_3^-	Nitrogen (Nitrate)
4500-O	Oxygen (Dissolved)
5020	Quality Assurance/Quality Control
5210	Biochemmical Oxygen Demand (BOD)
5310	Total Organic Carbon (TOC)
5910	UV-Absorbing Organic Constituents
6020	Quality Assurance/Quality Control
6810	Pharmaceuticals/Personal Care (New)
7010	Introduction
7020	Quality System
7040	Facilities
8010	Introduction
8020	Quality Assurance/Quality Control
8050	Bacterial Bioluminescence
8113	Marine Macroalgae
8310	Ciliated Protozoa
8510	Annelids
8610	Mollusks
8711	*Daphnia*
8712	*Ceriodaphnia*
8750	Aquatic Insects
8910	Fish
8921	Fathead Minnow

Section	Title
9020	Quality Assurance/Quality Control
9030	Laboratory Apparatus
9040	Washing and Sterilization
9050	Preparation of Culture Media
9060	Samples
9212	Stressed Microorganisms
9215	Heterotrophic Plate Count
9216	Direct Total Microbial Count
9221	Multiple-Tube Fermentation - Coliform
9222	Membrane Filter Technique - Coliforms
9223	Enzyme Substrate Coliform Test
9230	Fecal Enterococcus/Streptococcus Groups
9250	Detection of Actinomycetes
9610	Detection of Fungi
10900	Identification of Aquatic Organisms

In addition to these revised methods, a new method that did not make the book has also been added. 7110 D. Liquid Scintillation Method for Gross Alpha-Beta is now available.

Apologies for the lag between print and online edition releases. Thank you for your patience.

PREFACE TO THE TWENTY-THIRD EDITION

The Twenty-Second and Earlier Editions

The first edition of *Standard Methods* was published in 1905. Each subsequent edition has presented significant methodology improvements and enlarged the manual's scope to include techniques suitable for examining many types of samples encountered in the assessment and control of water quality and water pollution.

Standard Methods began as the result of an 1880s movement for "securing the adoption of more uniform and efficient methods of water analysis," which led to the organization of a special committee of the Chemical Section of the American Association for the Advancement of Science. An 1889 report of this committee, "A Method, in Part, for the Sanitary Examination of Water, and for the Statement of Results, Offered for General Adoption," covered five topics:

- "free" and "albuminoid" ammonia;
- oxygen-consuming capacity;
- total nitrogen as nitrates and nitrites;
- nitrogen as nitrites; and
- statement of results.*

Recognizing the need for standard methods in the bacteriological examination of water, members of the American Public Health Association (APHA) sponsored an 1895 convention of bacteriologists to discuss the problem. As a result, an APHA committee was appointed "to draw up procedures for the study of bacteria in a uniform manner and with special references to the differentiation of species." The procedures, which were submitted in 1897,† found wide acceptance.

In 1899, APHA appointed a Committee on Standard Methods of Water Analysis, charged with extending standard procedures to all methods involved in the analysis of water. The committee report, published in 1905, constituted the first edition of *Standard Methods* (then entitled *Standard Methods of Water Analysis*); it included physical, chemical, microscopic, and bacteriological methods of water examination. In its letter of transmittal, the Committee stated:

> The methods of analysis presented in this report as "Standard Methods" are believed to represent the best current practice of American water analysts, and to be generally applicable in connection with the ordinary problems of water purification, sewage disposal and sanitary investigations. Analysts working on widely different problems manifestly cannot use methods which are identical, and special problems obviously require the methods best adapted to them; but, while recognizing these facts, it yet remains true that sound progress in analytical work will advance in proportion to the general adoption of methods which are reliable, uniform and adequate.
>
> It is said by some that standard methods within the field of applied science tend to stifle investigations and that they retard true progress. If such standards are used in the proper spirit, this ought not to be so. The Committee strongly desires that every effort shall be continued to improve the techniques of water analysis and especially to compare current methods with those herein recommended, where different, so that the results obtained may be still more accurate and reliable than they are at present.

APHA published revised and enlarged editions under the title *Standard Methods of Water Analysis* in 1912 (Second Edition), 1917 (Third), 1920 (Fourth), and 1923 (Fifth). In 1925, the American Water Works Association (AWWA) joined APHA in publishing the Sixth Edition, which had the broader title: *Standard Methods of the Examination of Water and Sewage*. Joint publication was continued in the Seventh Edition (1933).

In 1935, the Federation of Sewage Works Associations [now the Water Environment Federation (WEF)] issued a committee report, "Standard Methods of Sewage Analysis."‡ With minor modifications, these methods were incorporated into the Eighth Edition (1936) of *Standard Methods*, which was thus the first to provide methods for examining "sewages, effluents, industrial wastes, grossly polluted waters, sludges, and muds." The Ninth Edition (1946) also contained these methods, and the Federation became a full-fledged publishing partner in 1947. Since then, the work of the *Standard Methods* committees of the three associations—APHA, AWWA, and WEF—has been coordinated by a Joint Editorial Board, on which all three are represented.

The Tenth Edition (1955) included methods specifically for examining industrial wastewaters; this was reflected by a new title: *Standard Methods for the Examination of Water, Sewage and Industrial Wastes.* In the Eleventh Edition (1960), the title was shortened to *Standard Methods for the Examination of Water and Wastewater* in order to describe the contents more accurately and concisely. The title has remained unchanged ever since.

In the Fourteenth Edition (1975), test methods for water were no longer separated from those for wastewater. All methods for analyzing a given component or characteristic appeared in a single section. With minor differences, the organization of the Fourteenth Edition was retained for the Fifteenth (1980) and Sixteenth (1985) Editions.

The Joint Editorial Board made two major policy decisions that were implemented in the Sixteenth Edition. First, the International System of Units (SI) was adopted, except where prevailing field systems or practices require English units. Second, the use of trade names or proprietary materials was eliminated as much as possible, to avoid potential claims regarding restraint of trade or commercial favoritism.

The organization of the Seventeenth Edition (1989) reflected a commitment to develop and retain a permanent numbering system. New numbers were assigned to all sections, and unused numbers were reserved for future use. All Part numbers were expanded to multiples of 1000 instead of 100. The Parts retained their identity from the previous edition, except Part 6000, which was reallocated from automated methods to methods for measuring specific organic compounds. The more general procedures for organics remained in Part 5000.

* *J. Anal. Chem.* 3:398 (1889).
† *Proc. Amer. Pub. Health Assoc.* 23:56 (1897).
‡ *Sewage Works J.* 7:444 (1935).

Also, Part 1000 underwent a major revision in the Seventeenth Edition, and sections dealing with statistical analysis, data quality, and methods development were greatly expanded.

The section on reagent water was updated to include a classification scheme for various types of reagent water. New sections were added at the beginning of Parts 2000 though 10 000 to address quality assurance (QA) and other matters of general application in the specific subject area; the intention was to minimize repetition in each Part.

The Eighteenth Edition (1992) included minor revisions to the new format and new methods in each Part.

In the Nineteenth Edition (1995), sections on laboratory safety and waste management were added to Part 1000. Substantial changes occurred throughout; many sections were revised and/or had new methods added.

Part 1000 was updated in the Twentieth Edition (1998), and substantial changes were made in introductory and quality control (QC) sections in various Parts (notably 3000 and 9000). New methods appeared in Parts 3000, 6000, and 8000. Most other sections were revised.

The Twenty-First Edition (2005) continued the trend to revise methods as issues were identified. The QA requirements in a number of Parts were refined, and new data on precision and bias were added. Several new methods were added to Parts 2000, 4000, 5000, 6000, 7000, 8000, and 9000, and numerous methods were revised.

The Twenty-First Edition methods appeared initially in *Standard Methods* Online (www.standardmethods.org), the Web site inaugurated in April 2004. Since then, all existing, revised, and new methods are available from this source, so *Standard Methods* users will always have access to the most current methods.

The signature undertaking of the Twenty-Second Edition (2012) was clarifying the QC measures necessary to perform the methods in this manual. Sections in Part 1000 were rewritten, and detailed QC sections were added in Parts 2000 through 7000. These changes are a direct and necessary result of the mandate to stay abreast of regulatory requirements and a policy intended to clarify the QC steps considered to be an integral part of each test method. Additional QC steps were added to almost half of the sections.

The Twenty-Third Edition

This edition continues the effort to clarify the QC measures for each method and to create consistency in the QC found in Section 1020 and Parts 2000 through 7000. References and bibliography were updated where necessary and language clarified in certain sections.

The Twenty-Third Edition contains more than 45 sections with significant technical/editorial revisions. Each section may also be found online.

More detailed information on revisions to the sections in the Twenty-Third Edition can be found in the title pages at the beginning of each Part.

Selection and Approval of Methods

For each new edition, both the technical criteria for selecting methods and the formal procedures for approving and including them are reviewed critically. In regard to approval procedures, it is considered particularly important to ensure that the methods presented have been reviewed and are supported by the largest number of qualified people, so they may represent a true consensus of expert opinion.

The system of using Joint Task Groups (initiated with the Fourteenth Edition) was continued for work on each section modified in the Twenty-Third Edition. Individuals generally are appointed to a Joint Task Group based on their expressed interest or recognized expertise in order to assemble a group with maximum available experience with each of the test methods of concern.

Each respective Joint Task Group was charged with review of the methods from the previous edition, review of current methodology in the literature, evaluation of new methods relevant to a Section, and the task of addressing any specific issues of concern that may have come to the attention of the Committee. Once a Joint Task Group was finished with and approved the work on a Section, the manuscript was edited and submitted to Standard Methods Committee members who had asked to review and vote on Sections in a given Part. The Joint Editorial Board reviewed every negative vote and every comment submitted during balloting. Relevant suggestions were referred appropriately for resolution. When negative votes on the first ballot could not be resolved by the Joint Task Group or the Joint Editorial Board, the section was re-balloted among all who voted affirmatively or negatively on the original ballot. Only a few issues could not be resolved in this manner, and the Joint Editorial Board made the final decision.

The general and specific QA/QC sections presented in Part 1000 and Sections 2020, 3020, 4020, 5020, 6020, and 7020 were treated somewhat differently for both the Twenty-Second and Twenty-Third Editions. For the Twenty-Second Edition, Joint Task Groups formed from the Part Coordinators and Joint Editorial Board members were charged with producing consensus drafts, which the Joint Editorial Board reviewed and edited via an iterative process. The draft sections were then sent to the Standard Methods Committee for review, and the resulting comments were used to develop the final drafts. The Twenty-Third Edition work on QC was an attempt by the Joint Editorial Board and Part Coordinators to refine and ensure consistency in these QC sections.

The methods presented here (as in previous editions) are believed to be the best available, generally accepted procedures for analyzing water, wastewaters, and related materials. They represent the recommendations of specialists, ratified by a large number of analysts and others of more general expertise, and as such are truly consensus standards, offering a valid and recognized basis for control and evaluation.

The technical criteria for selecting methods were applied by the Joint Task Groups and the individuals reviewing their recommendations; the Joint Editorial Board provided only general guidelines. In addition to the classical concepts of precision, bias, and minimum detectable concentration, method selection also must consider such issues as the time required to obtain a result, specialized equipment and analyst training needs, and other factors related to the cost of the analysis and the feasibility of its widespread use.

Status of Methods

All of the methods in the Twenty-Third Edition are dated to help users identify the year of approval by the Standard Methods Committee, and determine which ones changed significantly be-

tween editions. The year that a section was approved by the Standard Methods Committee is indicated in a footnote at the beginning of each section. Sections or methods from the Twentieth or Twenty-First Edition that are unchanged, or changed only editorially in the Twenty-Second Edition, show an approval date of 2004 or earlier. Sections or methods that were changed significantly or reaffirmed via general balloting of the Standard Methods Committee during approval of the Twenty-Second Edition, are dated 2005 through 2011. Sections or methods that were changed significantly or reaffirmed via general balloting of the Standard Methods Committee during approval of the Twenty-Third Edition, are dated after 2011. If only an individual method in a section was revised, its approval date is different from that of the rest of the section. Sections with only editorial revisions are noted as such (i.e., Editorial revisions, 2015) to make it easy for users to know whether a prior method is equivalent in protocol (exclusive of the QC issues). All references to individual *Standard Methods* sections should include the approval year in the reference (e.g., 5910-2011 or 5910-11) so users will know which version of the method was used and to facilitate the use of online versions of *Standard Methods*. In the Twenty-Third Edition, the Joint Task Groups that were active since the last full edition are listed at the beginning of each Part, along with a more detailed summary of changes in that Part.

Methods in the Twenty-Third Edition are divided into two fundamental classes: PROPOSED and STANDARD. Regardless of assigned class, all methods must be approved by the Standard Methods Committee. The classes are described as follows:

1. PROPOSED—A PROPOSED method must undergo development and validation that meets the requirements set forth in Section 1040A of *Standard Methods*.

2. STANDARD—A procedure qualifies as a STANDARD method in one of two ways:

a) The procedure has undergone development, validation, and collaborative testing that meet the requirements set forth in Sections 1040 of *Standard Methods*, and it is "WIDELY USED" by the members of the Standard Methods Committee; or

b) The procedure is "WIDELY USED" by the members of the Standard Methods Committee and it has appeared in *Standard Methods* for at least five years.

The Joint Editorial Board assigns method classifications. The Board evaluates the results of the survey on method use by the Standard Methods Committee, which is conducted when the method undergoes general balloting, and considers recommendations offered by Joint Task Groups and the Part Coordinator.

Methods categorized as "PROPOSED" are so designated in their titles; methods with no designation are "STANDARD."

Technical progress makes advisable the establishment of a program to keep *Standard Methods* abreast of advances in research and general practice. The Joint Editorial Board has developed the following procedure for effecting changes in methods:

1. The Joint Editorial Board may elevate any method from "proposed" to "standard" based on adequate published data supporting such a change (as submitted to the Board by the appropriate Joint Task Group). Notices of such a change in status shall be published in the official journals of the three associations sponsoring *Standard Methods* and uploaded to the *Standard Methods* Online Web site.
2. No method may be abandoned or reduced to a lower status without notification via the *Standard Methods* Online Web site.
3. The Joint Editorial Board may adopt a new proposed or standard method at any time, based on the usual consensus procedure. Such methods will be added to *Standard Methods* Online.

Reader comments and questions concerning this manual should be addressed to *Standard Methods* Technical Information Manager at www/standardmethods.org/contact/.

Acknowledgments

For the work in preparing and revising the methods in the Twenty-Third Edition, the Joint Editorial Board gives full credit to the Standard Methods Committees of the American Public Health Association, the American Water Works Association, and the Water Environment Federation. Full credit also is given to those individuals who were not members of the sponsoring societies. A list of all committee members follows these pages. The Joint Editorial Board is indebted to Steve Wendelken [U.S. Environmental Protection Agency (EPA), Office of Groundwater and Drinking Water], and Lemuel Walker (U.S. EPA Office of Science and Technology), who served as Liaisons to the Joint Editorial Board; thanks are due for their interest and help.

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PLATES

Black and white plates of aquatic organisms

Color plates of algae (special color section) following p. 10-176

Abbreviations

The following symbols and abbreviations are used throughout *Standard Methods:*

Abbreviation	*Referent*
AA	atomic absorption
A or amp	ampere(s)
AC	alternating current
ACS	American Chemical Society
amu	atomic mass units
APHA	American Public Health Association
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
BOD	biochemical oxygen demand
°C	degree(s) Celsius
c	counts
Ci	curie(s)
cm, cm^2, cm^3	centimeter(s), square centimeter(s), cubic centimeter(s)
COD	chemical oxygen demand
conc	concentrated
cpm	counts per minute
cps	counts per second
d	day(s)
DC	direct current
diam	diameter
DO	dissolved oxygen
DOX	dissolved organic halogen
dpm	disintegrations per minute
g	gram(s)
g	gravity, unit acceleration of
GC	gas chromatograph
GC/MS	gas chromatograph/mass spectrometer
h	hour(s)
HPLC	high-performance liquid chromatography
IC	ion chromatograph
ICP	inductively coupled plasma
ID	inside diameter
IU	international unit(s)
keV	kiloelectron volt(s)
kg	kilogram(s)
kPa	kilopascal
L	liter(s)
M	mole or molar
m, m^2, m^3	meter(s), square meter(s), cubic meter(s)
MCL	maximum contaminant level
MDL	method detection level
me	milliequivalent(s)
MeV	megaelectron volt(s)
mg	milligram(s)
min	minute(s)
mL	milliliter(s)
mm, mm^2, mm^3	millimeter(s), square millimeter(s), cubic millimeter(s)
mol wt	molecular weight
MPN	most probable number
MS	mass spectrometer
mV	millivolt(s)
μA	microampere(s)
μCi	microcurie(s)
μg	microgram(s)
μL	microliter(s)
μm	micrometer(s)
N	normal
nCi	nanocurie(s)
ng	nanogram(s)
NIST	National Institute of Standards and Technology
No.	number
NTU	nephelometric turbidity unit(s)
OD	outside diameter
Pa	pascal
pCi	picocurie(s)
pg	picogram(s)
PTFE	polytetrafluoroethylene
PVC	polyvinyl chloride
rpm	revolution(s) per minute
rps	revolution(s) per second
SD	standard deviation
SDI	sludge density index
s	second(s)
sp., spp.	species
sp gr	specific gravity
ST	standard taper
SVI	sludge volume index
TFE	tetrafluoroethylene
THM	trihalomethane(s)
TOC	total organic carbon
TON	threshold odor number
TOX	total organic halogen
Toxicity terms	*see* Section 8010B
U	unit(s)
USGS	U.S. Geological Survey
USP	United States Pharmacopoeia
UV	ultraviolet
V	volt(s)
v/v	volume ratio
W	watt(s)
WEF	Water Environment Federation
WPCF	*see* WEF

Abbreviations of periodical titles in reference lists and bibliographies are based on those given in *Biosis. List of Serials with Title Abbreviations*, 1970. Biosciences Information Service of Biological Abstracts, Philadelphia, Pa.

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General Information

TABLE A: UNIT PREFIXES

Symbol	Prefix	Multiples and Submultiples
M	mega-	10^{6}
k	kilo-	10^{3}
m	milli-	10^{-3}
μ	micro-	10^{-6}
n	nano-	10^{-9}
p	pico-	10^{-12}

TABLE B: METRIC-ENGLISH EQUIVALENTS

Metric Unit	Multipled by	= English Unit
m	3.279	ft
lux	0.0929	ft-c
L	0.2642	gal
cm	0.394	in.
kg	2.203	lb
g	0.0353	oz
kPa	0.145	psi

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Preparation of Common Types of Desk Reagents Specified in *Standard Methods*

Acid Solutions

Prepare the following reagents by cautiously adding required amount of concentrated acids, with mixing, to designated volume of proper type of distilled water. Dilute to 1000 mL and mix thoroughly.

See Table A for preparation of HCl, H_2SO_4, and HNO_3 solutions.

Alkaline Solutions

a. Stock sodium hydroxide, NaOH, 15*N* (for preparing 6*N*, 1*N*, and 0.1*N* solutions): Cautiously dissolve 625 g solid NaOH in 800 mL distilled water to form 1 L of solution. Remove sodium carbonate precipitate by keeping solution at the boiling point for a few hours in a hot water bath or by letting particles settle for at least 48 h in an alkali-resistant container (wax-lined or polyethylene) protected from atmospheric CO_2 with a soda lime tube. Use the supernate for preparing dilute solutions listed in Table B.

Alternatively prepare dilute solutions by dissolving the weight of solid NaOH indicated in Table B in CO_2-free distilled water and diluting to 1000 mL.

Store NaOH solutions in polyethylene (rigid, heavy-type) bottles with polyethylene screw caps, paraffin-coated bottles with rubber or neoprene stoppers, or borosilicate-glass bottles with rubber or neoprene stoppers. Check solutions periodically. Protect them by attaching a tube of CO_2-absorbing granular material such as soda lime or a commercially available CO_2-removing agent.* Use at least 70 cm of rubber tubing to minimize vapor diffusion from bottle. Replace absorption tube before it becomes exhausted. Withdraw solution by a siphon to avoid opening bottle.

* Ascarite II®, Arthur H. Thomas Co.; or equivalent.

Table B. Preparation of Uniform Sodium Hydroxide Solutions

Normality of NaOH Solution	Required Weight of NaOH to Prepare 1000 mL of Solution *g*	Required Volume of 15*N* NaOH to Prepare 1000 mL of Solution *mL*
6	240	400
1	40	67
0.1	4	6.7

b. Ammonium hydroxide solutions, NH_4OH: Prepare 5*N*, 3*N*, and 0.2*N* NH_4OH solutions by diluting 333 mL, 200 mL, and 13 mL, respectively, of the concentrated reagent (sp gr 0.90, 29.0%, 15*N*) to 1000 mL with distilled water.

Indicator Solutions

a. Phenophthalein indicator solution: Use either the aqueous (1) or alcoholic (2) solution.

1) Dissolve 5 g phenolphthalein disodium salt in distilled water and dilute to 1 L.

2) Dissolve 5 g phenolphthalein in 500 mL 95% ethyl or isopropyl alcohol and add 500 mL distilled water

If necessary, add 0.02*N* NaOH dropwise until a faint pink color appears in solution 1) or 2).

b. Methyl orange indicator solution: Dissolve 500 mg methyl orange powder in distilled water and dilute to 1 L.

Table A: Preparation of Uniform Acid Solutions*

Desired Component	Hydrochloric Acid (HCl)	Sulfuric Acid (H_2SO_4)	Nitric Acid (HNO_3)
Specific gravity (20/4°C) of ACS-grade conc acid	1.174–1.189	1.834–1.836	1.409–1.418
Percent of active ingredient in conc reagent	36–37	96–98	69–70
Normality of conc reagent	11–12	36	15–16
Volume (mL) of conc reagent to prepare 1 L of:			
18*N* solution	—	500 (1 + 1)†	—
6*N* solution	500 (1 + 1)†	167 (1 + 5)†	380
1*N* solution	83 (1 + 11)†	28	64
0.1*N* solution	8.3	2.8	6.4
Volume (mL) of 6*N* reagent to prepare 1 L of			
0.1*N* solution	17	17	17
Volume (mL) of 1*N* reagent to prepare 1 L of			
0.02*N* solution	20	20	20

*All values approximate.

†The *a* + *b* system of specifying preparatory volumes appears frequently throughout *Standard Methods* and means that *a* volumes of the concentrated reagent are diluted with *b* volumes of distilled water to form the required solution.

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Standard Atomic Weights 2015

[Scaled to $A_r(^{12}C) = 12$]

The atomic weights of many elements are not invariant but depend on the origin and treatment of the material. The standard values of $A_r(E)$ and the uncertainties (in parentheses, following the last significant figure to which they are attributed) apply to elements of natural terrestrial origin. The footnotes to this table elaborate the types of variation which may occur for individual elements and that may be larger than the listed uncertainties of values of $A_r(E)$. Names of elements with atomic number 113 to 118 are provisional.

Name	Symbol	Atomic Number	Atomic Weight	Footnotes
Actinium*	Ac	89		
Aluminum	Al	13	26.981 5386(7)	
Americium*	Am	95		
Antimony	Sb	51	121.760(1)	g
Argon	Ar	18	39.948(1)	g, r
Arsenic	As	33	74.921 595(6)	
Astatine*	At	85		
Barium	Ba	56	137.327(7)	
Berkelium*	Bk	97		
Beryllium	Be	4	9.012 182(5)	
Bismuth	Bi	83	208.980 40(1)	
Bohrium*	Bh	107		
Boron	B	5	10.81	m
Bromine	Br	35	79.904	
Cadmium	Cd	48	112.411(4)	g
Calcium	Ca	20	40.078(4)	g
Californium*	Cf	98		
Carbon	C	6	12.011	
Cerium	Ce	58	140.116(1)	g
Cesium	Cs	55	132.905 45196(6)	
Chlorine	Cl	17	35.45	m
Chromium	Cr	24	51.9961(6)	
Cobalt	Co	27	58.933 194(4)	
Copernicium*	Cn	112		
Copper	Cu	29	63.546(3)	r
Curium*	Cm	96		
Darmstadtium	Ds	110		
Dubnium*	Db	105		
Dysprosium	Dy	66	162.500(1)	g
Einsteinium*	Es	99		
Erbium	Er	68	167.259(3)	g
Europium	Eu	63	151.964(1)	g
Fermium*	Fm	100		
Flerovium*	Fl	114		
Fluorine	F	9	18.998 403 163(6)	
Francium*	Fr	87		
Gadolinium	Gd	64	157.25(3)	g
Gallium	Ga	31	69.723(1)	
Germanium	Ge	32	72.630(8)	
Gold	Au	79	196.966 569(5)	
Hafnium	Hf	72	178.49(2)	
Hassium*	Hs	108		
Helium	He	2	4.002 602(2)	g, r
Holmium	Ho	67	164.930 33(2)	
Hydrogen	H	1	1.008	m
Indium	In	49	114.818(1)	
Iodine	I	53	126.904 47(3)	
Iridium	Ir	77	192.217(3)	
Iron	Fe	26	55.845(2)	
Krypton	Kr	36	83.798(2)	g, m
Lanthanum	La	57	138.905 47(7)	g
Lawrencium*	Lr	103		
Lead	Pb	82	207.2(1)	g, r
Lithium	Li	3	[6.938; 6.997]	m
Livermorium*	Lv	116		
Lutetium	Lu	71	174.9668(1)	g
Magnesium	Mg	12	24.3050(6)	
Manganese	Mn	25	54.938 044(3)	
Meitnerium*	Mt	109		
Mendelevium*	Md	101		
Mercury	Hg	80	200.592(3)	
Molybdenum	Mo	42	95.95(1)	g
Moscovium*	Mc	115		
Neodymium	Nd	60	144.242(3)	g
Neon	Ne	10	20.1797(6)	g, m
Neptunium*	Np	93		
Nickel	Ni	28	58.6934(4)	
Nihonium*	Nh	113		
Niobium	Nb	41	92.906 37(2)	
Nitrogen	N	7	14.007	
Nobelium*	No	102		
Oganesson*	Og	118		
Osmium	Os	76	190.23(3)	g
Oxygen	O	8	15.999	
Palladium	Pd	46	106.42(1)	g
Phosphorus	P	15	30.973 761 998(5)	
Platinum	Pt	78	195.084(9)	
Plutonium*	Pu	94		
Polonium*	Po	84		
Potassium	K	19	39.0983(1)	
Praseodymium	Pr	59	140.907 66(2)	
Promethium*	Pm	61		
Protactinium*	Pa	91	231.035 88(2)	
Radium*	Ra	88		
Radon*	Rn	86		
Roentgenium*	Rg	111		
Rhenium	Re	75	186.207(1)	
Rhodium	Rh	45	102.905 50(2)	
Rubidium	Rb	37	85.4678(3)	g
Ruthenium	Ru	44	101.07(2)	g
Rutherfordium*	Rf	104		
Samarium	Sm	62	150.36(2)	g
Scandium	Sc	21	44.955 908(5)	
Seaborgium*	Sg	106		
Selenium	Se	34	78.971(8)	r
Silicon	Si	14	28.085	
Silver	Ag	47	107.8682(2)	g
Sodium	Na	11	22.989 769 28(2)	
Strontium	Sr	38	87.62(1)	g, r
Sulfur	S	16	32.06	
Tantalum	Ta	73	180.947 88(2)	
Technetium*	Tc	43		
Tellurium	Te	52	127.60(3)	g
Terbium	Tb	65	158.925 35(2)	
Thallium	Tl	81	204.38	
Thorium*	Th	90	232.0377(4)	g
Thulium	Tm	69	168.934 22(2)	
Tin	Sn	50	118.710(7)	g
Titanium	Ti	22	47.867(1)	
Tungsten	W	74	183.84(1)	
Uranium*	U	92	238.028 91(3)	g, m
Vanadium	V	23	50.9415(1)	
Xenon	Xe	54	131.293(6)	g, m
Ytterbium	Yb	70	173.045(10)	g
Yttrium	Y	39	88.905 84(2)	
Zinc	Zn	30	65.38(2)	r
Zirconium	Zr	40	91.224(2)	g

* Element has no stable nuclides.

g Geological specimens are known in which the element has an isotopic composition outside the limits for normal material. The difference between the atomic weight of the element in such specimens and that given in the Table may exceed the stated uncertainty.

m Modified isotopic compositions may be found in commercially available material because it has been subjected to an undisclosed or inadvertent isotopic fractionation. Substantial deviations in atomic weight of the element from that given in the table can occur.

r Range in isotopic composition of normal terrestrial material prevents a more precise $A_r(E)$ being given; the tabulated $A_r(E)$ value should be applicable to any normal material.

Source:International Union of Pure and Applied Chemistry. 2016. Atomic weights of the elements, 2013. *Pure Appl. Chem.* 88:265. www.chem.ac.uk/iupac/AtWt/

Some waters containing 250 mg Clâ€“/L may have a detectable salty taste if the cation is sodium. On the other hand, the typical salty taste may be absent in waters containing as much as 1000 mg/L when the predominant cations are calcium and magnesium. The chloride concentration is higher in wastewater than in raw water because sodium chloride (NaCl) is a common article of diet and passes unchanged through the digestive system. Along the sea coast, chloride may be present in high concentrations because of leakage of salt water into the sewerage system.