KIRK-OTHMER

## ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY

FOURTH EDITION VOLUME 1

# ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY

FOURTH EDITION

#### VOLUME 1

Apyright O'991 to Lun W. & Sore Lac.

OT sits received Published state tende 13;

after a diff a draw, was to monthly and ALKALOIDS and the door not too scratter by the but moved and the draws.

1976 United States Courages A a without the services of the copyright owner is up a while Requests Arrection rection of tertiher after after should on a carested to the Permissions Department at the Wiley & Salas Lat.

Library of Congress Faceloging-in-Publication Despites to be proceeded of chemical Lichardogy / executive utilities.

A Kroschwitz editor, Mary Howe-Grant - win ed.



A Wiley-Interscience Publication

JOHN WILEY & SONS

Printed to the "picod States of America

New York • Chichester • Brisbane • Toronto • Singapore

KIRK-OTHMER



VOLUME

Copyright © 1991 by John Wiley & Sons, Inc.

All rights reserved. Published simultaneously in Canada.

Reproduction or translation of any part of this work beyond that permitted by Sections 107 or 108 of the 1976 United States Copyright Act without the permission of the copyright owner is unlawful. Requests for permission or further information should be addressed to the Permissions Department, John Wiley & Sons, Inc.

#### Library of Congress Cataloging-in-Publication Data

Encyclopedia of chemical technology / executive editor, Jacqueline I. Kroschwitz; editor, Mary Howe-Grant. -4th ed.

At head of title: Kirk-Othmer.

"A Wiley-Interscience publication."

Includes index.

Contents: v. 1. A to alkaloids.

ISBN 0-471-52669-X (v. 1)

1. Chemistry, Technical—Encyclopedias. I. Kirk, Raymond E.

(Raymond Eller), 1890-1957. II. Othmer, Donald F. (Donald

Frederick), 1904 III. Kroschwitz, Jacqueline I., 1942 . IV. Howe-Grant, Mary, 1943 . V. Title: Kirk-Othmer encyclopedia of chemical technology.

technology.

TP9.E685 1991

660'.03-dc20

91-16789

CIP

HOY WELL

Printed in the United States of America

#### KIRK-OTHMER

## ENCYCLOPEDIA OF CHEMICAL TECHNOLOGY

torios Editor Vary Mowe-Grant FOURTH EDITION

VOLUME 1

A TO ALKALOIDS



### EXECUTIVE EDITOR Jacqueline I. Kroschwitz

Editor Mary Howe-Grant

此为试读,需要完整PDF请访问: www.ertongbook.com

## EDITORIAL STAFF

Angelo Bristovitzenia, GE Plantigs, Pittsfleid, Mussachusette LSS resina that er

CONTRIBUTORS TO VOLUME .

Karhein W. Geop. Fools. Cercin Valle, s. Pennsylvanii aurion B. Grocker. Consultant Cheste, edic nil seed. Air collus Senedicis Carelolo. R. Assaurch, sisselano Onio. Suryes acc

W. C. Etzkofta. Unika Serb de Jackala & Francs Com

Bugane V. Radi. C. of C. orodoro Wilmo New 1918 of Secondary

William M. Number, Calones, Canada Inc. Ed. acada Alberta.

Village L. In ward. T. e. C. . Observice. Company Greeport, Terlas, Acetonie

H & Magra seven Texas Listeran Covincia to 1

Executive Editor: Jacqueline I. Kroschwitz

Editor: Mary Howe-Grant

Editorial Supervisor: Michalina Bickford

Copy Editor: Lee Gray

### CONTRIBUTORS TO VOLUME 1

Lawrence E. Ball, BP Research, Cleveland, Ohio, Survey and SAN (under Acrylonitrile polymers)

William Bauer, Jr., Rohm and Haas Company, Spring House, Pennsylvania, Acrylic acid and derivatives

Tilak V. Bommaraju, Occidental Chemical Corporation, Niagara Falls, New York, Chlorine and sodium hydroxide (under Alkali and chlorine products)

John C. Bost, The Dow Chemical Company, Midland, Michigan, Halogenated derivatives (under Acetic acid and derivatives)

James F. Brazdil, BP Research, Cleveland, Ohio, Acrylonitrile

- Angelo Brisimitzakis, GE Plastics, Pittsfield, Massachusetts, ABS resins (under Acrylonitrile polymers)
- Kenneth W. Cooper, Poolpak, Inc., Seven Valleys, Pennsylvania, Air conditioning
- Burton B. Crocker, Consultant, Chesterfield, Missouri, Air pollution control methods
- Benedict S. Curatolo, BP Research, Cleveland, Ohio, Survey and SAN (under Acrylonitrile polymers)
- L. Calvert Curlin, OxyTech Systems, Inc., Chardon, Ohio, Chlorine and sodium hydroxide (under Alkali and chlorine products)
- David R. Dalton, Temple University, Philadelphia, Pennsylvania, Alkaloids
- Darwin D. Davis, E. I. du Pont de Nemours & Co., Inc., Victoria, Texas, Adipic acid
- W. G. Etzkorn, Union Carbide Chemicals & Plastics Company Inc., South Charleston, West Virginia, Acrolein and derivatives
- Michael Favaloro, Textron Defense Systems, Gloucester, Massachusetts, Ablative materials
- Leroy W. Fritch, Jr., GE Plastics, Pittsfield, Massachusetts, ABS resins (under Acrylonitrile polymers)
- Stanley A. Gembicki, UOP, Des Plaines, Illinois, Adsorption, liquid separation
- C. E. Habermann, Dow Chemical, USA, Midland, Michigan, Acrylamide
- H. J. Hagemeyer, Texas Eastman Company, Longview, Texas, Acetaldehyde
- Constance B. Hansson, Occidental Chemical Corporation, Dallas, Texas, Chlorine and sodium hydroxide (under Alkali and chlorine products)
- Eugene V. Hort, GAF Corporation, Wayne, New Jersey, Acetylene-derived chemicals
- William L. Howard, The Dow Chemical Company, Freeport, Texas, Acetone
- William N. Hunter, Celanese Canada Inc., Edmonton, Alberta, Canada, Alcohols, polyhydric
- Michael D. Jackson, Acurex Corporation, Mountain View, California, Alcohol fuels James A. Johnson, UOP, Des Plaines, Illinois, Adsorption, liquid separation
- Donald R. Kemp, E. I. du Pont de Nemours & Co., Inc., Victoria, Texas, Adipic acid Joseph Kozakiewicz, American Cyanamid Company, Stamford, Connecticut, Acrylamide polymers
- Donald M. Kulich, GE Plastics, Pittsfield, Massachusetts, ABS resins (under Acrylonitrile polymers)
- J. J. Kurland, Union Carbide Chemicals & Plastics Company Inc., South Charleston, West Virginia, Acrolein and derivatives
- George R. Lappin, Ethyl Corporation, Baton Rouge, Louisiana, Synthetic processes (under Alcohols, higher aliphatic)
- P. A. Larson, E. I. du Pont de Nemours & Co., Inc., Wilmington, Delaware, Dimethylacetamide (under Acetic acid and derivatives)
- David Lipp, American Cyanamid Company, Stamford, Connecticut, Acrylamide poly-
- R. P. Lukens, ASTM Committee E-43 on SI Practice, Woodbury, New Jersey, Conversion Factors, Abbreviations, and Unit Symbols
- David J. Miller, Union Carbide Chemicals & Plastics Corporation, South Charleston, West Virginia, Aldehydes

John D. Wagner, cliny

Earl D. Morris, The Dow Chemical Company, Midland, Michigan, Halogenated derivatives (under Acetic acid and derivatives)

coration Baton Rouge

- Carl B. Moyer, Acurex Corporation, Mountain View, California, Alcohol fuels
- Samuel Natansohn, GTE Laboratories, Inc., Waltham, Massachusetts, Structural ceramics (under Advanced ceramics)
- Jeffrey T. Neil, GTE Laboratories, Inc., Waltham, Massachusetts, Structural ceramics (under Advanced ceramics)
- W. D. Neilsen, Union Carbide Chemicals & Plastics Company Inc., South Charleston, West Virginia, Acrolein and derivatives
- Robert E. Newnham, Pennsylvania State University, University Park, Pennsylvania. Electronic ceramics (under Advanced ceramics)
- Alvin W. Nienow, University of Birmingham, Birmingham, United Kingdom, Biotechnology (under Aeration)
- Ronald W. Novak, Rohm and Haas Company, Spring House, Pennsylvania, Survey (under Acrylic ester polymers)
- J. T. O'Connor, Loctite Corporation, Newington, Connecticut, 2-Cyanoacrylic ester polymers (under Acrylic ester polymers)
- Anil R. Oroskar, UOP, Des Plaines, Illinois, Adsorption, liquid separation
- John E. Pace, GE Plastics, Pittsfield, Massachusetts, ABS resins (under Acrylonitrile polymers)
- Marina R. Pascucci, GTE Laboratories, Inc., Waltham, Massachusetts, Structural ceramics (under Advanced ceramics)
- Richard A. Peters, The Procter & Gamble Company, Cincinnati, Ohio, Survey and natural alcohols manufacture (under Alcohols, higher aliphatic)
- Alphonsus V. Pocius, The 3M Company, St. Paul, Minnesota, Adhesives
- Richard B. Rajendaen, Aeromix Systems, Inc., Minneapolis, Minnesota, Water treatment (under Aeration)
- Frank Rauh, FMC Corporation, Princeton, New Jersey, Sodium carbonate (under Alkali and chlorine products)
- Charles V. Rue, Norton Company, Worcester, Massachusetts, Abrasives
- **Douglas M. Ruthven,** University of New Brunswick, Fredricton, New Brunswick, Canada, Adsorption
- John J. Sciarra, Sciarra Aeromed Development Corporation, Brooklyn, New York, Aerosols
- **Glenn T. Seaborg,** *University of California, Berkeley, Berkeley, California,* Actinides and transactinides
- John D. Sherman, UOP, Tarrytown, New York, Adsorption, gas separation
- Thomas R. Shrout, Pennsylvania State University, University Park, Pennsylvania, Electronic ceramics (under Advanced ceramics)
- John B. Starr, Hoechst Celanese Corporation, Summit, New Jersey, Acetal resins
- Paul Taylor, GAF Corporation, Wayne, New Jersey, Acetylene-derived chemicals
- Urs von Stockar, École Polytechnique Fédérale, Lausanne, Switzerland, Absorption
- Frank S. Wagner, Jr., Nandina Corporation, Corpus Christi, Texas, Acetamide; Acetic acid; Acetic anhydride; Acetyl chloride (all under Acetic acid and derivatives)

- John D. Wagner, Ethyl Corporation, Baton Rouge, Louisiana, Synthetic processes (under Alcohols, higher aliphatic)
- J. C. Watts, E. I. du Pont de Nemours & Co., Inc., Wilmington, Delaware, Dimethylacetamide (under Acetic acid and derivatives)
- Charles R. Wilke, University of California, Berkeley, Berkeley, California, Absorption George T. Wolff, General Motors, Warren, Michigan, Air pollution
- Carmen M. Yon, UOP, Tarrytown, New York, Adsorption, gas separation
- J. Richard Zietz, Ethyl Corporation, Baton Rouge, Louisiana, Synthetic processes (under Alcohols, higher aliphatic)

Rosen E. Hewmann, Pennsylvania Silvie C. Nors IV. Uriver, in Cark, Februardeania

Bonnid W. Novale, Porch and Haas Company, S. ding house Ji emisy wanta. Survey

man E. Prog. CE Mashus That Washachuletts HBS mura under Acry on the

Maring R. Pascucci, G.T. .. Coramnics, unt. Waltham, Messachusaite Segenural

Richard A. Paters, The Promer's Jambie Common y Oricle off, Unio, Survey and

Mchard & Resendance, Aeromix Systems, inc. Minneanolis Mannesola Stor treat-

Frank Baub. FVC Climaration. Franceton His sciences Sadtum carbonate Cinder

Douglas M. Ruihven, Laversity of No. Brunswick ersonuton New Brunswick, Can-

John J., Scierca. Science Careformen Caronalian. Brupi vn. new York.

Glenn T. Seabora, Luda etv of Calife Mar Rendley Benevey California Actinides

Thomas R. Swort, Panns, vania State Utiversity, University Park, Fan Sylvania

John B. Carr. Hiseofist Colonesis Conjugation, Surject New Jersey, Acetal resinance Paus Teytor, Gab. Corporation, Wayne were direct. Acetyl ine derived chemicals, this valuational stocker, acoth Polytech, inthe Federala, Lausanne Swirgman, Abscription Frank S. Magner, Br.: Vandina Corporation, Carous Carles, Texas Acetamide Acetite and Acetic rathernos. Acetyl chloride (all linds) Aceth acid and a crivatives).

apple we black and translady of Bird in Juan Burn agham. Tuesd kick do no

Ant R. Creskar, 609. End fall is filled a cust of the depict containing

Nishansus V Fortun The 3M Octionary a Part Moneyor Adhesives

Challes V. Rue, No ion Company W. reste. Well acousells. Abrasivas

tonn C Sherman UCP, Tarretown Man York, Adsorption, das secaration

Electronic caramica (andor Movemed ceremics)

ceramics tunde Advances ceramics)

Alkall and enloring products)

#### **PREFACE**

The Fourth Edition of the Encyclopedia of Chemical Technology is built on the solid foundation of the previous editions and also looks forward into the 21st century. The First Edition, published between 1949 and 1956, demonstrated the enormous progress the American chemical industry made during World War II and the postwar period. The Second Edition, published between 1963 and 1972, reflected the chemical industry as an international enterprise with the interchange of experience and know-how on a global scale. The Third Edition, published between 1978 and 1984, continued the presentation of the best worldwide practices in the process technologies and emphasized topics of great concern to all scientists and engineers, ie, energy, safety, and the environment.

The Fourth Edition is in many ways an entirely new encyclopedia in a format familiar to those acquainted with the earlier editions. All of the articles in this new edition have been rewritten and updated and many new subjects have been added, reflecting changes in chemical technology since the Third Edition. The results, however, will be familiar to the users of the earlier editions: comprehensive, authoritative, accessible, lucid.

The use of SI units as well as common units, Chemical Abstracts Services Registry Numbers, and complete indexing based on automated retrieval from a machine-readable composition system continue. The *Encyclopedia* is an indispensible information source for all producers and users of chemical products and materials.

New subjects have been added, especially in biotechnology, computer topics, analytical techniques and instrumentation, environmental concerns, fuels and energy, inorganic and solid state chemistry, composite materials and materials science in general, and pharmaceuticals.

The Fourth Edition could not be published without the assistance of the many advisors, reviewers, chemists, and engineers who have given their advice and guidance. To all of them our thanks is due.

#### PREFACE

The Fourth Edition of the fire school of the miral line by a built at the sold foundation of the previous directs and also reals be marked in the 21st contain. The Eirst Edition, published between 1843 and 1850 demonstrated the marmous progress, the innerion rhemical industry made during World War II and the postwar period. The Second Edition, published between 196, and 1972, reflected rife chemical industry as at interactional enterprise with the intercellment experience and know in a glain scale. The Third Edition published between 1978 and 1984, controlled the presentation of the best worldwide practices in the process technologies and emphasized technical enterprise and traineers, he marry, sates and the cavin quant.

The Evarth Edgmon is a many ways an entirely new encyclopedia in a formet lamiliar to those acquainted with the corber editions. All or the articles in this new calling have been rewritten and updated and many new subjects have been added, referring changes in cremical technology sine its Third Edition. The results however will be familian to the user of the partial editions; comprehensive archeringly, accessible, lucid

The vise of SI-units as well as common units. Chemical Abstracts convices Registry Numbers, and complete indexing based on automated reprieval from a machine-readable, composition system continue. The Eurycopedia is, in indispensible information source for all producers and users of chemical products and materials.

New subjects have been added, especially in protecturingly, computer topics, analytic. I techniques and instrumentation environmental concerns, hiels and energy, marganic and solid state chemistry, composite materials and materials science in general, and pharmaceuticals.

The Fourth Edition could not be published without the assistance of the many advisors, reviewers, chemists, and engineers who have given their advice and guidance. To all of them our thanks is due.

under Fluorine sempounds ino

## ently. The article Chlored arbons and chlorehydrogarbons con industrially imported MOITSUCOSTALINATION well as carbon, hydrogen, and chlorenge as carbon.

went as carbon, nyanogen, and chorine are somethors, growned to corone. Chlorophender, Chlorophender, Chlorophender, Chlorophender, confermations treated as derived twee under a carent

In general, the treatment of a compound will be found either unless own name, or under a group of substances (for example, or vl acreade under Esters organic) of as a derivative under a parent compound (for example, edy) are whater

compound thus chlorosmil nes appear he derivatives unde

Organic compounds containing fluorine (with or widness other listogens) are discussed under Fluorine compounds, organic There are also arthress on Brotaine compounds and ioding compound. Chlorine is treated somewhat afficer

Organometallies. However, fluoring, in its industrial applies tions, is so different from the other halogers that the metallic fluorides are usually grouped together

The main subject of the *Encyclopedia* is chemical technology, and about one-half of all the articles deal with chemical substances, either single substances, such as Sulfuric acid, or groups of substances, such as Aluminum compounds. There are also articles on industrial processes, such as Alkylation; on uses, such as Abrasives; Adhesives; on pharmaceuticals, dyes, fibers; on foods and other human uses, such as Cosmetics. There are articles on the unit operations and unit processes of chemical engineering; on fundamentals, such as Absorption; Mass transfer; and on scientific and technological subjects, such as Catalysis, Color, Electrochemical processing, Magnetic materials, and Ultrasonics. Still other articles deal with such general subjects as Computer technology, Information retrieval, Patents, Regulatory agencies, Technical service, and Transportation.

In general, the properties and manufacture of any substance are given in one article, which makes cross reference to one or more articles where the uses of that substance are described. Thus the manufacture of fused alumina is described under Aluminum compounds, but for its uses the reader will be directed to such articles as Abrasives and Refractories.

For inorganic compounds, in some cases it is the anion, in others the cation that has the greater industrial significance. Thus calcium phosphate, sodium phosphate, and ammonium phosphate are important primarily as phosphates and are discussed under Phosphoric acid and phosphates. Similarly, chromates and borates are under Chromium compounds and Boron compounds, respectively, and salts of organic acids (except acetates and formates) are discussed with the acids. On the other hand, barium chloride, barium nitrate, and barium sulfate would be thought of together and are therefore described in Barium compounds. In general, compounds of the following anions are dealt with in articles such as Aluminum compounds and Calcium compounds: acetates; carbonates; formates; chlorides, bromides, and iodides (under halides); nitrates; nitrites; oxides (including hydroxides and oxygen acids and their salts, but excluding true peroxides); sulfates; sulfites; and sulfides. The organic compounds of a metal, containing a metal-tocarbon bond, are also discussed with the compounds of that metal or under

Organometallics. However, fluorine, in its industrial applications, is so different from the other halogens that the metallic fluorides are usually grouped together

under Fluorine compounds, inorganic.

Organic compounds containing fluorine (with or without other halogens) are discussed under Fluorine compounds, organic. There are also articles on Bromine compounds and Iodine compounds. Chlorine is treated somewhat differently. The article Chlorocarbons and chlorohydrocarbons covers a large number of industrially important compounds; compounds containing other elements as well as carbon, hydrogen, and chlorine are sometimes grouped together (as, Chlorophenols; Chlorohydrins), sometimes treated as derivatives under a parent compound (thus chloroanilines appear as derivatives under Amines, aromatic, aniline).

In general, the treatment of a compound will be found either under its own from name, or under a group of substances (for example, ethyl acetate under Esters, organic), or as a derivative under a parent compound (for example, ethyl acrylate under Acrylic acid and derivatives). The cross references provided will, it is hoped, in almost all cases direct the reader to the appropriate part of the

Encyclopedia.

cid. or erungs of substances, such a Anamificia, o apoun slap article or undust. As process as sub as Alleviation on uses, st. F as Abra s ca. Au estverton pharmaceuticals, tyes, fibers on foods and ther hum a vigesuch as Cosmetics. There are aniches on the unit operations and unit processes of cheriscal in timesting on fundamentals, such as Absorption, Mass les afer and on scientific and technological subsects, such as Catalys's Color, blection he man cal processing. Movnetic materials and Ultrasoner, Still outer anteles deal with such general subjects as Computer technology, information retrieval Patents, Regulatory exencus, acchaical service, and Tanaports, on.

ingeneral the proprints and manufacture fanys stance are grown in one aviete, which is alies erose reference to one or more articles while the good of that water Aluminum campounds, but for its less the reader will directed to such articles as Abrasives and Robactories.

for increanic compounds, in some case it is the anion in cohers the cartier shosphate, and anymoultan phosphate are supercent primarily as phosphates and are discussed under thospheric old and plans haves Simplarly obvor ites and borsten araunder El romium con pounds and Boron compounds respectively, and salts of occanic words is cent acreates and formates) are discussed with the acres On the caper pand, british chloride, believe glante, and barium suifate could be thought conjugated and are therefore described in Berium compounds in general compound of the following actors are dealt with in articles such as Alemenum compositional del um compounds acetatics carbonates formares; chlosides. be and oxygen acres and their saits, but excluding true perfordes), sulfalest sulfites, and sulfides. The organic cour ounds of a metal contenting a metal-toearbon bond, are also discussed with the controunds of that metal or ander

## NOTE ON CHEMICAL ABSTRACTS SERVICE REGISTRY NUMBERS AND NOMENCLATURE

bonds and are maricity are shown in the harvean

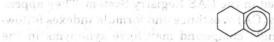
Chemical Abstracts Service (CAS) Registry Numbers are unique numerical identifiers assigned to substances recorded in the CAS Registry System. They appear in brackets in the Chemical Abstracts (CA) substance and formula indexes following the names of compounds. A single compound may have synonyms in the chemical literature. A simple compound like phenethylamine can be named β-phenylethylamine or, as in Chemical Abstracts, benzeneethanamine. The usefulness of the Encyclopedia depends on accessibility through the most common correct name of a substance. Because of this diversity in nomenclature careful attention has been given to the problem in order to assist the reader as much as possible, especially in locating the systematic CA index name by means of the Registry Number. For this purpose, the reader may refer to the CAS Registry Handbook-Number Section which lists in numerical order the Registry Number with the Chemical Abstracts index name and the molecular formula; eg. 458-88-8, Piperidine, 2-propyl-, (S)-, C<sub>8</sub>H<sub>17</sub>N; in the Encyclopedia this compound would be found under its common name, coniine [458-88-8]. Alternatively, this information can be retrieved electronically from CAS Online. In many cases molecular formulas have also been provided in the Encyclopedia text to facilitate electronic searching. The Registry Number is a valuable link for the reader in retrieving additional published information on substances and also as a point of access for on-line data bases.

In all cases, the CAS Registry Numbers have been given for title compounds in articles and for all compounds in the index. All specific substances indexed in *Chemical Abstracts* since 1965 are included in the CAS Registry System as are a large number of substances derived from a variety of reference works. The CAS Registry System identifies a substance on the basis of an unambiguous computer-language description of its molecular structure including stereochemical detail. The Registry Number is a machine-checkable number (like a Social Security number) assigned in sequential order to each substance as it enters the registry system. The value of the number lies in the fact that it is a concise and unique means of substance identification, which is independent of, and therefore bridges,

many systems of chemical nomenclature. For polymers, one Registry Number may be used for the entire family; eg, polyoxyethylene (20) sorbitan monolaurate has the same number as all of its polyoxyethylene homologues.

Cross-references are inserted in the index for many common names and for some systematic names. Trademark names appear in the index. Names that are incorrect, misleading, or ambiguous are avoided. Formulas are given very frequently in the text to help in identifying compounds. The spelling and form used, even for industrial names, follow American chemical usage, but not always the usage of Chemical Abstracts (eg, coniine is used instead of (S)-2-propylpiperidine, aniline instead of benzenamine, and acrylic acid instead of 2-propenoic acid).

There are variations in representation of rings in different disciplines. The dye industry does not designate aromaticity or double bonds in rings. All double bonds and aromaticity are shown in the *Encyclopedia* as a matter of course. For example, tetralin has an aromatic ring and a saturated ring and its structure



appears in the *Encyclopedia* with its common name, Registry Number enclosed in brackets, and parenthetical CA index name, ie, tetralin [119-64-2] (1,2,3,4-tetrahydronaphthalene). With names and structural formulas, and especially with CAS Registry Numbers, the aim is to help the reader have a concise means of substance identification.

Registry Number. For this nurpose, the reader may refer to the CAS Registry Handbook - Number Section which lists of numerical order the Registry Nomber with the Chemical Abstracts and a came and the molecular formula: eq. 458-85-8, Provided a compound would be found and a reserve compound would be found and a reserve the compound would be can be one in our electronically from AS Online in many cases molecular formulas. In we also be an a covided to the Exception text to facilitate electronic search of The Registry Number is a valiable link for the reader in intrieving additional published information of access for solutions have been

In ally close the CAS key stry Numbers have been given for title compounds in articles and for all compounds in the index AB specific substances indexed in CAS Registry System as any a large number or substances derived from a variety of reference works. The CAS Registry System as any a Recentry System as a large number or substances derived from a variety of reference works. The CAS Registry System of the molecular structure including starfochemical lateil. In anguage description of the molecular structure including starfochemical lateil and the Registry Number is a machine check while number filler a Social Security and be a suggest in see cutian are in case on the fact that registry system. The value of the momenthes in the fact that it is a concise and unique means of substance in the fact that there are bridges.

DERIVED UNITS AND OTHER ACCEPTABLE

#### CONVERSION FACTORS, ABBREVIATIONS, AND UNIT SYMBOLS

derived up its (2 4). These of eved units having special names and symbols

#### SI Units (Adopted 1960)

supplementary units, and other

r JoV

The International System of Units (abbreviated SI), is being implemented throughout the world. This measurement system is a modernized version of the MKSA (meter, kilogram, second, ampere) system, and its details are published and controlled by an international treaty organization (The International Bureau of Weights and Measures) (1).

SI units are divided into three classes:

#### BASE UNITS

length the mass resident to the mass resident to the description of the mass resident to the modynamic temperature amount of substance remains the minimum intensity

meter (m) which we will be wil

大海传统教 Billion g

#### SUPPLEMENTARY UNITS

plane angle solid angle

radian (rad) steradian (sr)

†The spellings "metre" and "litre" are preferred by ASTM; however "-er" is used in the Encyclopedia.

<sup>‡</sup>Wide use is made of Celsius temperature (t) defined by

 $t = T - T_0$ 

where T is the thermodynamic temperature, expressed in kelvin, and  $T_0=273.15~\mathrm{K}$  by definition. A temperature interval may be expressed in degrees Celsius as well as in kelvin.

#### DERIVED UNITS AND OTHER ACCEPTABLE UNITS

These units are formed by combining base units, supplementary units, and other derived units (2-4). Those derived units having special names and symbols are marked with an asterisk in the list below.

Quantity A	ONVERS ON Unit	Symbol	Acceptable equivalent
*absorbed dose acceleration	gray meter per second squared	Gy m/s <sup>2</sup>	J/kg
*activity (of a radionuclide)	becquerel	Bq	1/s
area	square kilometer square hectometer square meter	km <sup>2</sup> hm <sup>2</sup> m <sup>2</sup>	ha (hectare)
concentration (of amount of substance)	mole per cubic meter		Si. Johs (Ad:
current density	ampere per square meter	A/m <sup>2</sup>	Internat
density, mass density	kilogram per cubic meter	kg/m³	g/L; mg/cm <sup>3</sup>
dipole moment (quantity) *dose equivalent *electric capacitance	coulomb meter sievert farad	C·m Sv F	J/kg C/V
*electric charge, quantity of electricity	çoulomb	C C/m <sup>3</sup>	SASE UN
electric charge density	meter	2 71	
*electric conductance property electric field strength electric flux density.	volt per meter	$S$ emit $TV/m$ do $S$ $C/m^2$ may use to the same $TV/m$	A/V
*electric potential, y of hose potential difference,		luminou- <b>V</b> n	A/W
electromotive force *electric resistance *energy, work, quantity of heat	ohm megajoule kilojoule	Ω MJ kJ	V/A
or near	joule	J eV <sup>†</sup>	N·m
"At his wayer of an asi of the	electronvolt <sup>†</sup> kilowatt-hour <sup>†</sup>	$kW \cdot h^{\dagger}$	The Spelli Scoolgodia
energy density *force	joule per cubic meter kilonewton	$J/m^3$ sham a $kN$	kg·m/s²

This non-SI unit is recognized by the CIPM as having to be retained because of practical importance or use in specialized fields (1).