

Hawley's
**CONDENSED
CHEMICAL
DICTIONARY**

Eleventh Edition

Hawley's Condensed Chemical Dictionary

ELEVENTH EDITION

Revised by

N. Irving Sax

and

Richard J. Lewis, Sr.



VAN NOSTRAND REINHOLD
New York

Copyright © 1987 by Van Nostrand Reinhold

Library of Congress Catalog Card Number 86-23333
ISBN 0-442-28097-1

All rights reserved. Certain portions of this work copyright © 1930, 1920, 1919 by The Chemical Catalog Co., Inc. and 1981, 1977, 1971, 1966, 1956, 1950 by Van Nostrand Reinhold. No part of this work covered by the copyright hereon may be reproduced or used in any form or by any means—graphic, electronic, or mechanical, including photocopying, recording, taping, or information storage and retrieval systems—without permission of the publisher.

Printed in the United States of America

Van Nostrand Reinhold
115 Fifth Avenue
New York, New York 10003

Chapman & Hall
2-6 Boundary Row
London SE1 8HN, England

Thomas Nelson Australia
102 Dodds Street
South Melbourne, Victoria 3205, Australia

Nelson Canada
1120 Birchmount Road
Scarborough, Ontario M1K 5G4, Canada

15 14 13 12 11 10 9 8 7 6 5

Library of Congress Cataloging-in-Publication Data

Condensed chemical dictionary.
Hawley's condensed chemical dictionary.

Rev. ed. of: The Condensed chemical dictionary.
10th ed./rev. by Gessner G. Hawley, 1981.

1. Chemistry—Dictionaries. I. Hawley, Gessner
Goodrich, 1905— II. Sax, N. Irving (Newton Irving)

III. Lewis, Richard J., Sr. IV. Title.

QD5.C5 1987 540'.3'21 86-23333

ISBN 0-442-28097-1

*Hawley's
Condensed Chemical
Dictionary*

**In fond memory
of
our good friend
Gessner G. Hawley**

To
Pauline and Grace
for their unending support and assistance

Our gratitude to Alberta W. Gordon and Carol P. Wickell for
their professional assistance with the production of this book

Introduction

The first edition of the *Condensed Chemical Dictionary* appeared in 1919, when the chemical industry in the United States was entering a huge expansion program as a result of World War I. The urgent need for such a reference book became apparent to Francis M. Turner, President of the Chemical Catalog Company, predecessor of the Reinhold Publishing Corporation. Under his supervision a succession of Editors developed and expanded the *Condensed Chemical Dictionary* to meet the growing needs of the chemical industries. Since his death this development has continued, with the result that the work has achieved worldwide recognition in its field.

The Condensed Chemical Dictionary is a unique publication. It is not a dictionary in the usual sense of a compilation of brief definitions, but rather a compendium of technical data and descriptive information covering many thousand chemicals and chemical phenomena, organized in such a way as to meet the needs of those who have only minutes to devote to any given substance or topic.

Three distinct types of information are presented: (1) descriptions of chemicals, raw materials, processes and equipment; (2) expanded definitions of chemical entities, phenomena, and terminology; and (3) description or identification of a wide range of trademarked products used in the chemical industries. Supplementing these are listings of accepted chemical abbreviations used in the literature, short biographies of chemists of historic importance, and descriptions or notations of the nature and location of many American technical societies and trade associations. In special cases editorial notes have been supplied where it was felt necessary to clarify or amplify a definition or description. A few entries written by specialists are acknowledged by use of the author's name.

In a work of this nature, selection of topics for inclusion can hardly fail to be influenced by current interests and developing concerns within the topic area. The growing importance to chemists, and to the general public as well, of environmental and health hazards, which came to the forefront so quickly in the 1960s was reflected in the Eighth Edition, which greatly increased its coverage of this

aspect of chemistry. After that, the magnitude of the energy problem became uppermost in the thinking of a broad spectrum of engineers, chemists, and physicists, since it has certainly become one of the most important technical problems confronting this country. Both the Ninth and Tenth Editions, while retaining emphasis on environmental considerations, were expanded in the area of energy and its sources, as far as permitted by available information. The effort in the eleventh edition has been to provide condensed, authoritative, factually oriented statements and descriptions, and to resist prognostications as to the future potential of any particular energy source. At the same time, continuing attention has been devoted to common hazards, such as flammable and explosive materials, poisons, pesticides, carcinogens, corrosive agents, radioactive wastes, etc., in line with the practice followed in earlier editions, and with the increasing public concern over these matters.

In connection with certain classifications of substances, particularly pesticides and carcinogens, which have occasioned the most controversy, the statement "Use may be restricted" indicates that a state or local regulation may exist even though the product has not been officially banned, or that a definitive ruling on its use is pending. When a product has been banned outright, the statement "Use has been prohibited" is used. A number of disputed cases have arisen in recent years; though some have been definitely settled, others are still being evaluated or are in the process of litigation, for example, saccharin.

In such a work as this, in view of the many materials in various stages of evaluative testing, court procedures, appeals, hearings, etc., it is impossible to keep abreast of every development. The user should check the current status of any questionable products before making decisions that involve them (see also paragraph on Hazards, below).

Arrangement of Entries

The entries are listed in strict alphabetical order; that is, those comprised of two or more words are alphabetized as if they were a single word, e.g.,

"acidimetry" precedes "acid value," and "water-proofing agent" precedes "water softener." Many of the prefixes used in organic chemistry are disregarded in alphabetizing, since they are not considered an integral part of the name; these include ortho- (o-), meta- (m-), para- (p-), alpha (α), beta (β), gamma (γ), sec-, tert-, sym-, as-, uns-, cis-, trans-, endo-, exo-, d-, l-, dl-, n-, N-, O-, as well as all numerals denoting structure. However, there are certain prefixes that are an integral part of the name (iso-, di-, tri-, tetra-, cyclo-, bis-, neo-, pseudo-), and in these cases the name appears in its normal alphabetical position, e.g., dimethylamine under "D" and isobutane under "I." The same is true of mono- (used as little as possible) and of ortho-, and meta-, in inorganic compounds such as sodium orthophosphate.

Chemicals and Raw Materials

The information in the categories listed below is given for each substance in the sequence indicated; where entries are incomplete, it may be presumed that no reliable data were provided by the reference systems utilized.

Name: The commonly accepted name is the key entry. Terminological variations are indicated where necessary. In virtually all cases, the name is given in the singular number. A name having initial caps and enclosed in quotes is a trademark (TM). The superior numbers refer to the name of the manufacturer given in Appendix III.

Synonym: Alternate names (IUPAC and others), as well as trivial names, are indicated. Obsolete and slang names have been eliminated as far as possible. Most synonyms are entered independently and cross-referenced, but space limitation has not permitted complete consistency in this regard.

Chemical Abstract Service Registry Numbers (CAS): In this Eleventh Edition of the *Condensed Chemical Dictionary* in order to make it a part of the vast accumulation of chemical, physical, and toxicological data which presently exists in the scientific literature in general, we have for the first time included the American Chemical Society's Chemical Abstract Service Registry Numbers (CAS) for many of the chemical entries. This will make the Eleventh Edition harmonize with the worldwide scientific literature. It will permit use and comparison of data on a given material no matter under what synonym it might be published. It will, in fact, permit absolute identification of a compound with all of its synonyms.

Formula: The molecular (or atomic) formula is regularly given. Structural formulas are used in special cases of unusual importance or interest.

Properties: The properties typically given are: physical state, atomic number, atomic weight, valence, isotopes, odor, taste, density, boiling point (at 760 mm Hg unless otherwise stated), melting point (freezing point), refractive index, and solubility or miscibility. Various other properties are given where pertinent: flash point, autoignition point, electrical properties, tensile strength, hardness, expansion coefficient, etc.

Source or Occurrence: Geographical origin of metals, ores, essential oils, vegetable oils, and other natural products.

Derivation: The chemical reactions or other means of obtaining the product by current industrial methods are emphasized. Obsolete and "curiosity" methods have been largely eliminated.

Grade: Recognized grades as reported in the industrial literature, including technical, CP, USP, refined, reactor, semiconductor, etc.

Hazard: This category includes flammability, toxicity characterization, explosion risks, etc., based on authoritative data. Also given are the Threshold Limit Values (TLV) for workroom exposures established by the American Conference of Government Industrial Hygienists; and various rulings of the Food and Drug Administration.

It was not considered practicable to include occupational exposure recommendations made by the National Institute for Occupational Safety and Health or exposure standards established by the Occupational Safety and Health Administration.

The toxicity ratings are intended to be used only as indications of the industrial hazard presented by a given material, as most of them are based on tests made on laboratory animals. Qualified toxicologists or physicians should be consulted for specific evaluations, dosages, exposure times, and concentrations. For further information regarding these hazards, the reader is referred to the following entries: combustible material; flammable material; dust, industrial; corrosive material; oxidizing material; poison (1); toxicity; toxic materials; carcinogen.

Use: These are primarily large-scale applications. Because of the rapidity of change in the chemical industries and the difficulty of obtaining reliable current data, no attempt has been made to list uses in the order of their tonnage consumption.

The patent literature is not specifically represented.

Shipping Regulations: For some years, revised regulations for transportation labeling of hazardous materials have been issued annually by the International Air Transport Association of Geneva, Switzerland (IATA) and by the U.S. Department of Transportation (DOT). For this reason, it has been decided to discontinue listing of specific labeling requirements in this book, as has been customary throughout its publishing history. Though these have always been taken directly from the most recent available schedules, so many additions and changes in the official regulations are made each year that it is impossible to keep them up to date in a publication that extends over a four- or five-year period. Thus, any such endeavor has to be less than 100% accurate and may result in costly and even dangerous misinterpretations. Therefore, manufacturers and shippers of chemicals and related products should procure and utilize the "restricted articles," schedules established by the agencies referred to.

The presence of the notation "Shipping regulations" in the description of a substance indicates a strong probability that a labeling requirement exists; however, absence of this notation does not necessarily mean that the substance is unregulated. The only valid sources of this information are the current revision of the IATA Restricted Articles Regulations (for air transport) and the Hazardous Materials Regulations of the U.S. Department of Transportation. The former may be ordered from the International Air Transport Association, 26 Chemin de Joinville, Box 160, 1216 Cointrin, Geneva, Switzerland; the latter can be obtained from R. M. Graziano, Association of American Railroads, 1920 L St., N.W., Washington, D.C. 20036.

General Entries

It is likely that no two editors would completely agree about what general subjects should be included in a dictionary of this kind. The major subdivisions of matter directly involved with chemical reactions, the various states of matter, and the more important groups of compounds would almost certainly be regarded as essential; but beyond these, the area of selectivity widens rapidly. The topics either added or expanded by the present Editors were chosen chiefly because of their interest and importance, both industrial and biochemical, and secondarily because of the terminological confusion evidenced in the literature and in industrial practice. Regarding the latter, the reader is referred to the entries on gum, resin, pigment, dye, filler,

extender, reinforcing agent, homogeneous, and combustible materials. In some cases a position has been taken which may not be accepted by all, but which is defensible and certainly not arbitrary. Even Editors must acknowledge that the meanings and uses of terms often change illogically, and that such changes are usually irreversible.

Among the general entries are: important subdivisions of chemistry; short biographies of outstanding chemists of the past including all winners of the Nobel Prize for Chemistry; numerous group definitions (barbiturate, peroxide); major chemical and physicochemical phenomena (polymerization, catalysis); functional names (antifreeze, heat-exchange agent); terms describing special material forms (aerosol, foam, fiber); energy sources (solar cell, fuel cell, fusion); the more important chemical processes; and various types of machinery and equipment used in the process industries. No general entry is intended to be encyclopedic or definitive, but rather a condensation of essential information, to be supplemented by reference to specialized sources. To present all this in useful and acceptably complete form has been a challenging, though often frustrating task, which the Editors leave with the uneasy feeling that, like the breadcrumbs in the Hatter's butter, some mistakes may have got in as well.

Trademarks

Continuing the policy of previous editions, an essential component of the Dictionary comprises descriptions of several thousand proprietary industrial products. The information was either provided by the manufacturers of these materials or taken from announcements or advertisements appearing in the technical press. Each proprietary name is enclosed in quotation marks, is stated to be a trademark (or brand name), and is followed by a superscript number referring to the Numerical List of Manufacturers in Appendix III. From this, the address of the manufacturer can easily be found in the alphabetical List of Manufacturers contained in Appendix IV. We wish to thank the owners of these trademarks for making the information available. The space devoted to these is necessarily limited, as the constant proliferation of trademarked products makes it impossible to list more than a small fraction of them in a volume such as this.

The absence of a specific trademark designation does not mean that proprietary rights may not exist in a particular name. No listing, description, or designation in this book is to be construed as affecting the scope, validity, or ownership of any trademark rights that may exist therein. Neither the Editors nor the Publisher assumes any responsibility for the accuracy of any such description, or for the validity or ownership of any trademark.

*Acknowledgments***A Request**

Many corrections and suggestions have been made from readers during the long history of the earlier editions. The Editors have always tried to acknowledge these to the best of their ability. They have welcomed this correspondence, for it has been an important source of information about the ac-

ceptance of the Dictionary by its readers. The present Editors and Publisher wish to encourage this reaction from the field, not only to permit corrections to be made in reprints, but also as a basis for preparing future editions. All letters addressed to the Publisher will be forwarded to the Editors.

N. Irving Sax
Richard J. Lewis, Sr.

Abbreviations

ACS	American Chemical Society	mg	milligram
atm	atmosphere	mg/m ³ , mg/m ³	milligrams per cubic meter
ASTM	American Society for Testing and Materials	μCi/mL	microcuries per milliliter
autoign temp	autoignition temperature	μg/m ³	microgram per cubic meter
aw	atomic weight	mi	Curie
bp	boiling point	min	minimum, minute(s)
Btu	British thermal unit	m-	meta
C	degrees centigrade (Celsius)	mm	millimeter
CAS	Chemical Abstracts Service registry number	mp	melting point
cc	cubic centimeter	Mw, mw	molecular weight
CC	closed cup	N.D.	"New Drugs"
C.I.	"Colour Index" (a standard British publication giving official numerical designations to colorants).	NF	National Formulary grade of chemical
CL	ceiling level	N.F.	"National Formulary"
CP	chemically pure: a grade designation signifying a minimum of impurities, but not 100% purity.	NIOSH	National Institute for Occupational Safety and Health
cp	centipoise	nm	nanometers
COC	Cleveland Open Cup	o-	ortho
cu	cubic	OC	Open Cup
cu/ft/lb	cubic feet per pound	OSHA	Occupational Safety and Health Administration
d, D	density	p-	para
DOT	Department of Transportation	ppb	parts per billion
DOTC	Department of Transportation Classification	ppm	parts per million
e.g.	for example	psi(a)	pounds per square inch (absolute)
F	degrees Fahrenheit	%	percent
FCC	"Food Chemicals Codex"	refr	refractive
FDA	Food and Drug Administration	sec	second
flash p	flash point	sp vol	specific volume
fp	freezing point	TCC	Tagliabue Closed Cup
ft	feet	TLV	threshold limit value
FTC	Federal Trade Commission (a consumer protection agency).	TM	trademark
g	gram	TOC	Tagliabue Open Cup
gal	gallon	USAN	United States Adopted Name
g/L	grams per liter	USDA	U.S. Department of Agriculture
g/mL	grams per milliliter	U.S.P.	United States Pharmacopeia
HOH, H ₂ O	water	UV	ultraviolet
Hg	mercury	vap press	vapor pressure
hr	hour	wt/gal	weight per gallon
i.e.	that is		
L, l	liter		
lb(s)	pound (pounds)		
lb/gal	pounds per gallon		

Greek Letters

α	alpha
β	beta
ω	omega
γ	gamma
μ	mu
Δ	delta

Contents

INTRODUCTION	ix
ABBREVIATIONS	xiii
CONDENSED CHEMICAL DICTIONARY	1
APPENDIX I: ORIGIN OF SOME CHEMICAL TERMS	1265
APPENDIX II: HIGHLIGHTS IN THE HISTORY OF CHEMISTRY	1272
APPENDIX III: MANUFACTURERS OF TRADEMARKED PRODUCTS (Numerical List)	1279
APPENDIX IV: MANUFACTURERS OF TRADEMARKED PRODUCTS (Alphabetical List)	1283

A

α. See alpha.

A. (1) Abbreviation for absolute temperature; (2) abbreviation for Angstrom.

AAAS. Abbreviation of American Association for Advancement of Science.

abaca. (Manila hemp). The strongest vegetable fiber, obtained from the leaves of a tree of the banana family. The fibers are 4–8 feet long, light in weight, soft, lustrous, nearly white, and do not swell or lose strength when wet. Denier ranges from 300 to 500. Combustible, but self-extinguishing.

Sources: Philippines, Central America, Sumatra. Use: Heavy cordage and twine, especially for marine use; manila paper. See also hemp.

“abate.”⁵⁷ TM for insecticide. CAS: 3383-96-8. [(CH₃O)₂ PSOC₆H₄]₂S.

Properties: Colorless crystals, mp 30C.

Hazard: Toxic by ingestion and inhalation. Cholinesterase inhibitor. TLV: 10 mg/m³ of air.

Use: Pesticide.

Abel-Pensky. A standard test for flash point.

abherent. Any substance that prevents adhesion of a material to itself or to another material. It may be in the form of a dry powder (a silicate such as talc, mica, or diatomaceous earth); a suspension (bentonite-water); a solution (soap-water); or soft solid (stearic acid, tallow waxes). Abherents are used as dusting agents and mold washes in the adhesives, rubber and plastics industries. Fats and oils are used as abherents in the baking industry. Fluorocarbon resin coatings on metals are widely used on cooking utensils. See also antiblock agent; dusting agent.

Abies Siberica oil. See fir needle oil.

abietic acid. (abietinic acid; sylvic acid).

C₁₉H₂₉COOH (having a phenanthrene ring system). A major active ingredient of rosin, where it occurs with other resin acids. The term is often applied to these mixtures, separation of which is not achieved in technical grade material. Properties: Yellowish, resinous powder; mp 172–175C; optical rotation –106; soluble in alcohol,

ether, chloroform, and benzene; insoluble in water. Combustible.

Derivation: Rosin, pine resin; tall oil.

Method of purification: Crystallization.

Grade: Technical.

Use: Abietates (resinates) of heavy metals as varnish driers; esters in lacquers and varnishes; fermentation industries; soaps.

“ABITOL.”²⁶⁶ TM for a colorless, tacky, very viscous liquid; mixture of tetra-, di-, and dehydroabietyl alcohols made from rosin.

Use: Plasticizers, tackifiers, adhesive modifiers.

ablative material. Any material that possesses a capability for rapidly dissipating heat from a substrate. Specialized ceramic tiles developed since 1980 for protection of the space shuttle have proved successful. The materials used are of two major types: (1) Fibers made from white silica, fused in an oven, cut into blocks, and coated with borosilicate glass; these are extremely efficient at temperatures up to 2300F. (2) An all-carbon composite (called reinforced carbon-carbon) made by laminating and curing layers of graphite fiber previously coated with a resin, which is pyrolyzed to carbon. The resulting tile is then treated with a mixture of alumina, silicon, and silicon carbide. Such composites are used for maximum-temperature (nose-cone) exposure up to 3000F. Both types are undamaged by the heat and are reusable. The tiles are adhered to the body of the spacecraft with a silicone adhesive. Ablative materials used on early spaceship trials were fluorocarbon polymers and glass-reinforced plastics, but these were wholly or partially decomposed during reentry.

abrasion. Gradual erosion of the surface of a material both by physical forces (simultaneous cutting, shearing, and tearing) and by chemical degradation, chiefly oxidation. Temperature is a significant factor: friction may raise the temperature of the surface layers to the point where they become subject to chemical attack. Abrasion causes deterioration of many materials, especially of rubber (tire treads), where it can be offset by a high percentage of carbon black; other materials subjected to abrasion in their service life are textiles (laundering), leather and plastics

(shoe soles, belting), house paints and automobile lacquers (airborne dust, grit, etc.).
See also abrasive.

abrasive. A finely divided, hard, refractory material, ranging from 6 to 10 on the Mohs scale, used to reduce, smooth, clean, or polish the surfaces of other, less hard substances, such as glass, plastic, stone, wood, etc. Natural abrasive materials include diamond dust, garnet, sand (silica), corundum (aluminum oxide, emery), pumice, rouge (iron oxide), and feldspar; the more important synthetic types are silicon carbide, boron carbide, cerium oxide, and fused alumina. Abrasive in powder form may be (1) applied directly to the surface to be treated by mechanical pressure or compressed-air blast, as in cleaning building stone; (2) affixed to paper or textile backing after the particles have been coated with an adhesive; or (3) mixed with a bonding agent such as sodium silicate or clay, the particles being compressed into a wheel rotated by a power-driven shaft. A relatively recent development (1983) is an aluminum grinding wheel to which industrial diamonds are bonded with fluorocarbon polymer ("Teflon"). The process involves reaction of fluorine with the surfaces of the diamonds, chemical bonding of the fluorinated diamonds to the fluorocarbon, and further chemical bonding of the resulting material to the aluminum with application of heat and pressure.

abrasive, coated. See abrasive (2).

ABS. Abbreviation for (1) alkyl benzene sulfonate (detergent); (2) acrylonitrile-butadiene-styrene copolymer.
See ABS resin.

"absafil."⁵³⁹ TM for an acrylonitrile-butadiene-styrene copolymer reinforced with glass fiber.
See also reinforced plastic.

abscisic acid. $C_{15}H_{20}O_4$. A plant growth regulator that promotes detachment of leaves and fruit.

Properties: Colorless crystals; mp 160°C; sublimes at 120°C; soluble in acetone, ether, chloroform; slightly soluble in water. Optically active.

Occurrence: In plants, fruits, and vegetables from which it can be extracted. Also made synthetically.

Use: In orchard sprays to facilitate fruit harvesting; defoliant; growth inhibitor.

absinthium. (wormwood). ($C_{30}H_{40}O_7$).

An essential oil with intensely bitter taste due to presence of absinthin.

Hazard: Toxic by ingestion.

Use: A flavoring in liqueurs, vermouth.

absolute. (1) Free from admixture of other substances; pure. Example: absolute alcohol is dehydrated ethanol, 99% pure. (2) The pure essential oil obtained by double solvent extraction of flowers in the manufacture of perfumes.
See concrete (2). (3) Absolute temperature.

absolute temperature. The fundamental temperature scale used in theoretical physics and chemistry, and in certain engineering calculations such as the change in volume of a gas with temperature. Absolute temperatures are expressed either in degrees Kelvin or in degrees Rankine, corresponding respectively to the centigrade and Fahrenheit scales. Degrees Kelvin are obtained by adding 273 to the centigrade temperature (if above 0°C) or subtracting the centigrade temperature from 273 (if below 0°C). Degrees Rankine are obtained by subtracting 460 from the Fahrenheit temperature. The closest approach to absolute zero is -272°C.

absorbent. (1) Any substance exhibiting the property of absorption, e.g., absorbent cotton, so made by removal of the natural waxes present.
See absorption (1).

(2) A material that does not transmit certain wavelengths of incident radiation.
See absorption (2).

absorption. (1) In chemical terminology, the penetration of one substance into the inner structure of another, as distinguished from adsorption, in which one substance is attracted to and held on the surface of another. Physicochemical absorption occurs between a liquid and a gas or vapor, as in the operation known as scrubbing in which the liquid is called an absorption oil; sulfuric acid, glycerol, and some other liquids absorb water vapor from the air under certain conditions. Physiological absorption takes place via porous tissues, such as the skin and intestinal walls, which permit passage of liquids and gases into the bloodstream.

See also adsorption; hygroscopic.

(2) In physical terminology, retention by a substance of certain wavelengths of radiation incident upon it, followed by either an increase in temperature of the substance or by a compensatory change in the energy state of its molecules. The UV component of sunlight is absorbed as the light passes through glass and some organic compounds, the radiant energy being transformed into thermal energy. The radiation-absorptive capacity of matter is utilized in analyti-

cal chemistry in various types of absorption spectroscopy.

(3) In physical chemistry, the ability of some elements to pick up or "capture" thermal neutrons produced in nuclear reactors as a result of fission. This is due to the large capture cross section of their atoms, which is measured in units called, "barns;" elements of particularly high neutron absorption capability are cadmium and boron.

absorption band. The range of wavelengths absorbed by a molecule; for example, absorption in the infrared band of 2.3 to 3.2 μ indicates the presence of OH and NH groups, while the 3.3 to 3.5 μ band indicates aliphatic structure. Atoms absorb only a single wavelength, producing lines, such as the sodium D line.

See also spectroscopy; resonance (2); UV absorber; excited state.

absorption oil. See absorption (1).

absorption spectroscopy. An important technique of instrumental analysis involving measurement of the absorption of radiant energy by a substance as a function of the energy incident upon it. Absorption processes occur throughout the electromagnetic spectrum, ranging from the gamma region (nuclear resonance absorption or the Mossbauer effect) to the radio region (nuclear magnetic resonance). In practice, they are limited to those processes that are followed by the emission of radiant energy of greater intensity than that which was absorbed. All absorption processes involve absorption of a photon by the substance being analyzed. If it emits the excess energy by emitting a photon of less energy than that absorbed, fluorescence or phosphorescence occurs, depending on the lifetime of the excited state.

The emitted energy is normally studied. If the source of radiant energy and the absorbing species are in identical energy states, i.e., in resonance, the excess energy is often given up by the nondirectional emission of a photon whose energy is identical with that absorbed.

Either absorption or emission may be studied, depending upon the chemical and instrumental circumstances. If the emitted energy is studied, the term "resonance fluorescence" is often used. However, if the absorbing species releases the excess energy in small steps by the process of intermolecular collision or some other mode, it is commonly understood that this phenomenon falls within the realm of absorption spectroscopy. The terms absorption spectroscopy, spectrophotometry, and absorptimetry are often used synonymously.

Most absorption spectroscopy is done in the

ultraviolet, visible, and infrared regions of the electromagnetic spectrum.

See also emission spectroscopy; infrared spectroscopy.

ABS resin. Any of a group of tough, rigid thermoplastics deriving their name from the three letters of the monomers which produce them.

acrylonitrile-butadiene-styrene resin. Most contemporary ABS resins are true graft polymers consisting of an elastomeric polybutadiene or rubber phase, grafted with styrene and acrylonitrile monomers for compatibility, dispersed in a rigid styrene-acrylonitrile (SAN) matrix. Mechanical polyblends of elastomeric and rigid copolymers, e.g., butadiene-acrylonitrile rubber and SAN, historically the first ABS resins, are also marketed.

Varying the composition of the polymer by changing the ratios of the three monomers and use of other comonomers and additives results in ABS resins with a wide range of properties.

Properties: Dimensional stability over temperature range from -40 to $+71^{\circ}\text{C}$. Attacked by nitric and sulfuric acids, and by aldehydes, ketones, esters, and chlorinated hydrocarbons. Insoluble in alcohols, aliphatic hydrocarbons, mineral and vegetable oils. Processed by conventional molding and extrusion methods. D 1.04; tensile strength about 6500 psi; flexural strength 10,000 psi; good electrical resistance; water absorption 0.3–0.4%. Combustible, but slow-burning; flame retardants may be added. Can be vacuum-metalized or electroplated.

Grade: High-, medium-, and low-impact; molding and extrusion.

Use: Engineering plastics used for automobile body parts and fittings; telephones; bottles; heels; luggage; packaging; refrigerator door liners; plastic pipe and building panels (subject to local building codes); shower stalls; boats; radiator grills; machinery housings; business machines.

Note: Several trademarked types are "Cyclocac," "Abson," Kralastic, Lustran. For further information, refer to Society of Plastics Industry, 355 Lexington Ave., New York, NY 10017.

abundance. The relative amount (% by weight) of a substance in the earth's crust, including the atmosphere and the oceans.

(a) The abundance of the elements in the earth's crust is:

Rank	Element	% by wt.
1	Oxygen	49.2
2	Silicon	25.7
3	Aluminum	7.5
4	Iron	4.7
5	Calcium	3.4

Rank	Element	% by wt.
6	Sodium	2.6
7	Potassium	2.4
8	Magnesium	1.9
9	Hydrogen	0.9
10	Titanium	0.6
11	Chlorine	0.2
12	Phosphorus	0.1
13	Manganese	0.1
14	Carbon	0.09
15	Sulfur	0.05
16	Barium	0.05
	all others	0.51

(b) The percentages of inorganic compounds in the earth's crust, exclusive of water, are:

(1) SiO_2 55 (2) Al_2O_3 15 (3) CaCO_3 8.8
(4) MgO 1.6 (5) Na_2O 1.6 (6) K_2O 1.9

(c) The most abundant organic materials are cellulose and its derivatives, and proteins. *Note:* On the universal scale, the most abundant element is hydrogen.

Ac. Symbol for actinium; abbreviation for acetate.

AC. Abbreviation for allyl chloride.

acacia gum. See arabic gum.

acaricide. A type of pesticide effective on mites and ticks (acarides).

"Accel."¹²³ TM for a lactic acid starter culture for use in food processing.

accelerator. (1) A compound, usually organic, that greatly reduces the time required for vulcanization of natural and synthetic rubbers, at the same time improving the aging and other physical properties. Organic accelerators invariably contain nitrogen, and many also contain sulfur. The latter type are called ultra-accelerators because of their greater activity. The major types include amines, guanidines, thiazoles, thiuram sulfides, and dithiocarbamates. The amines and guanidines are basic, the others acidic. The normal effective concentration of organic accelerators in a rubber mixture is 1% or less based on the rubber hydrocarbon present. Zinc oxide is required for activation, and in the case of acidic accelerators, stearic acid is required. The introduction of organic accelerators in the early twenties was largely responsible for the successful development of automobile tires and mechanical products for engineering uses. A few inorganic accelerators are still used in low-grade products, e.g., lime, magnesium oxide, and lead oxide. See also vulcanization; rubber.

(2) A compound added to a photographic developer to increase its activity, such as certain quaternary ammonium compounds and alkaline substances.

(3) A particle accelerator.
acceptability (foods).
See organoleptic.

acceptable risk. A concept that has developed in recent years, especially in connection with toxic substances (insecticides, mercurials, carcinogens), food additives, air and water pollution, and related environmental concerns. It may be defined as a level of risk at which a seriously adverse result is highly unlikely to occur, "but at which one *cannot* prove whether or not there is 100% safety. It means living with reasonable assurance of safety and acceptable uncertainty." (Schmutz, J. F., C&EN, Jan. 16, 1978). Examples of acceptable risk that might be cited are diagnostic x-rays, fluoridation of water, and ingestion of saccharin in normal amounts.

The acceptability of the risks involved in nuclear power generation is controversial. The weight of the evidence has tended to shift toward the negative side since 1975 when an official safety study estimated the risk of a serious accident to be 1 in 20,000 years of reactor operation. An investigation made by the Oak Ridge National Laboratory based on data collected from 1969 to 1979 concluded that the risk of a major accident is 1 in 1000 years of reactor operation.

acceptor. See donor.

acenaphthene. (1,8-dihydroacenaphthalene; ethylenenaphthalene). $\text{C}_{10}\text{H}_8(\text{CH}_2)_2$ (a tricyclic compound).
Properties: White needles; d 1.024 (99/4C); fp 93.6C; bp 277.5C; refr index (100C) 1.6048. Soluble in hot alcohol; insoluble in water. Combustible.

Derivation: From coal tar.

Grade: Technical; 98%.

Use: Dye intermediate; pharmaceuticals; insecticide; fungicide; plastics.

acenaphthenequinone. (1,2-acenaphthenedione).

$\text{C}_{10}\text{H}_6(\text{CO})_2$ (a tricyclic compound).

Properties: Yellow needles; mp 261–263C; insoluble in water; soluble in alcohol.

Derivation: By oxidizing acenaphthene, using glacial acetic acid and sodium or potassium dichromate.

Grade: Technical.

Use: Dye synthesis.

acenocoumarin. (3-(α -acetyl-4-nitrobenzyl)-4-hydroxycoumarin). $\text{C}_{19}\text{H}_{15}\text{NO}_6$.

Properties: White, crystalline powder; tasteless

and odorless; mp 197°C. Slightly soluble in water and organic solvents.

Use: Medicine (anticoagulant).

acephate. (acetylphosphoramidothioic acid ester). CAS: 30560-19-1. $C_4H_{10}NO_3PS$. Properties: White crystals; mp 65°C; soluble in water; slightly soluble in acetone and alcohol. Hazard: Moderately toxic by ingestion. Use: Insecticide.

acetadol. See aldol.

acetal. (diethylacetal; 1,1-diethoxyethane; ethylidenediethyl ether). CAS: 105-57-7. $CH_3CH(OC_2H_5)_2$. Properties: Colorless, volatile liquid; agreeable odor; nutty aftertaste. Stable to alkalis, but readily decomposed by dilute acids. Forms a constant-boiling mixture with ethanol. Soluble in alcohol, ether, and water. D 0.831; bp 103–104°C; vap press 20.0 mm (20°C); flash p -5F (CC) (-20.5°C); specific heat 0.520; refr index 1.38193 (20°C); wt (lb/gal) 6.89; autoign temperature 446F (230°C). Derivation: Partial oxidation of ethanol the acetaldehyde first formed condensing with the alcohol. Grades: Technical. Hazard: Highly flammable. Dangerous fire risk. Explosive limits in air 1.65 to 10.4%. Moderately toxic and narcotic in high concentrations. Use: Solvent; cosmetics; organic synthesis; perfumes; flavors. See also acetal resin.

acetaldehyde. (acetic aldehyde; aldehyde; ethanal; ethyl aldehyde). CAS: 75-07-0. CH_3CHO . Properties: Colorless liquid; pungent, fruity odor. D 0.783 (18/4°C); bp 20.2°C; mp -123.5°C; vap press 740.0 mm (20°C); flash p -40F (-40°C) (OC); specific heat 0.650; refr index 1.3316 (20°C); wt 650 lb/gal (20°C); miscible with water, alcohol, ether, benzene, gasoline, solvent naphtha, toluene, xylene, turpentine, and acetone. Derivation: (a) Oxidation of ethylene; (b) vapor phase oxidation of ethanol; (c) vapor-phase oxidation of propane and butane; (d) catalytic reaction of acetylene and water (chiefly in Germany). Grade: Technical 99%.

Hazard: Highly flammable; toxic (narcotic). Dangerous fire, explosion risk. Explosive limits in air 4 to 57%. TLV: 100 ppm in air. Use: Manufacture of acetic acid and acetic anhydride, n-butanol, 2-ethylhexanol, peracetic acid, aldol, pentaerythritol, pyridines, chloral, 1,3-butylene glycol, and trimethylolpropane; synthetic flavors.

acetaldehyde ammonia. See aldehyde ammonia.

acetaldehyde cyanohydrin. See lactonitrile.

acetal resin. (polyacetal). A polyoxymethylene thermoplastic polymer obtained by ionically initiated polymerization of formaldehyde + CH_2 to obtain a linear molecule of the type $-O-CH_2-O-CH_2-CH_2-$. Single molecules may have over 1500 $-CH_2-$ units. As the molecule has no side chains, dense crystals are formed. Acetal resins are hard, rigid, strong, tough, and resilient; dielectric constant 3.7; dielectric strength 1200 volts/mil, 600 volts/mil (80-mil); dimensionally stable under exposure to moisture and heat, resistant to chemicals, solvents, flexing and creep, and have a high gloss and low friction surface. Can be chromium-plated, injection-molded, extruded, and blow-molded. Not recommended for use in strong acids or alkalis. They may be homopolymers or copolymers.

Properties: D 1.425; thermal conductivity 0.13 Btu/hr/sq ft/degree F/ft; coefficient of thermal expansion 4.5×10^{-5} /degree F; specific heat 0.35 Btu/lb/degree F; water absorption 0.41%/24 hour; tensile strength 10,000 psi; elongation 15%; hardness (Rockwell) R120; impact strength (notched) 1.4 ft-lb/inch; flexural strength 14,100 psi; shear strength 9500 psi. Combustible, but slow burning.

Use: An engineering plastic, often used as substitute for metals, as oil and gas pipes; automotive and appliance parts; industrial parts; hardware; communication equipment; aerosol containers for cosmetics.

See also "Delrin"; "Celcon."

acetamide. (acetic acid amine; ethanamide). CAS: 60-35-5. CH_3CONH_2 .

Properties: Colorless, deliquescent crystals with a mousy odor. Soluble in water and alcohol; slightly soluble in ether; d 1.159; mp 80°C; bp 223°C; refr index 1.4274 (78.3°C). Combustible. Derivation: Interaction of ethyl acetate and ammonium hydroxide.

Grade: Technical; CP (odorless); intermediate; reagent.

Hazard: An experimental carcinogen.

Use: Organic synthesis (reactant, solvent, peroxide stabilizer); general solvent; lacquers; explosives; soldering flux; hygroscopic agent; wetting agent; penetrating agent.

acetamidine hydrochloride. $C_2H_6N_2HCl$.

Properties: Crystalline solid; slightly deliquescent; mp 166°C; soluble in water and alcohol; insoluble in acetone. Keep stoppered.

Derivation: Alcohol solution of acetonitrile + HCl + ammonia.

Hazard: Skin irritant. Moderately toxic by ingestion.