

ULLMANN'S Seventh Edition ENCYCLOPEDIA OF INDUSTRIAL CHEMISTRY

Ullmann's Encyclopedia of Industrial Chemistry

7th, Completely Revised Edition

Volume 8

Cereals

to

Chloroformic Esters



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Volume 8

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Symbols and Units

Symbols and units agree with SI standards (for conversion factors see page IX). The following list gives the most important symbols used in the encyclopedia. Articles with many specific units and symbols have a similar list as front matter.

Symbol	Unit	Physical Quantity
a_B		activity of substance B
A_r		relative atomic mass (atomic weight)
A	m^2	area
c_B	mol/m^3 , mol/L (M)	concentration of substance B
C	C/V	electric capacity
c_p, c_v	$J\,kg^{-1}\,K^{-1}$	specific heat capacity
d	cm , m	diameter
d		relative density (ρ/ρ_{water})
D	m^2/s	diffusion coefficient
D	Gy ($=J/kg$)	absorbed dose
e	C	elementary charge
E	J	energy
E	V/m	electric field strength
E	V	electromotive force
E_A	J	activation energy
f		activity coefficient
F	C/mol	Faraday constant
F	N	force
g	m/s^2	acceleration due to gravity
G	J	Gibbs free energy
h	m	height
$\hbar$	$W\cdot s^2$	Planck constant
H	J	enthalpy
I	A	electric current
I	cd	luminous intensity
k	(variable)	rate constant of a chemical reaction
k	J/K	Boltzmann constant
K	(variable)	equilibrium constant
l	m	length
m	g , kg , t	mass
M_r		relative molecular mass (molecular weight)
n_D^{20}		refractive index (sodium D-line, 20 °C)
n	mol	amount of substance
N_A	mol^{-1}	Avogadro constant ($6.023 \times 10^{23}\,mol^{-1}$)
P	Pa , bar^*	pressure
Q	J	quantity of heat
r	m	radius
R	$JK^{-1}\,mol^{-1}$	gas constant
R	Ω	electric resistance
S	J/K	entropy
t	s , min , h , d , $month$, a	time
t	$^{\circ}C$	temperature
T	K	absolute temperature
u	m/s	velocity
U	V	electric potential

Symbols and Units (Continued from p. VII)

Symbol	Unit	Physical Quantity
U	J	internal energy
V	m^3 , L, mL, μL	volume
w		mass fraction
W	J	work
x_B		mole fraction of substance B
Z		proton number, atomic number
α		cubic expansion coefficient
α	$\text{Wm}^{-2}\text{K}^{-1}$	heat-transfer coefficient (heat-transfer number)
α		degree of dissociation of electrolyte
$[\alpha]$	$10^{-2}\text{deg cm}^2\text{g}^{-1}$	specific rotation
η	$\text{Pa}\cdot\text{s}$	dynamic viscosity
θ	$^{\circ}\text{C}$	temperature
κ		c_p/c_v
λ	$\text{Wm}^{-1}\text{K}^{-1}$	thermal conductivity
λ	nm, m	wavelength
μ		chemical potential
ν	Hz , s^{-1}	frequency
ν	m^2/s	kinematic viscosity (η/ρ)
π	Pa	osmotic pressure
ρ	g/cm^3	density
σ	N/m	surface tension
τ	Pa (N/m^2)	shear stress
Φ		volume fraction
χ	Pa^{-1} (m^2/N)	compressibility

*The official unit of pressure is the pascal (Pa).

Conversion Factors

SI unit	Non-SI unit	From SI to non-SI multiply by
<i>Mass</i>		
kg	pound (avoirdupois)	2.205
kg	ton (long)	9.842×10^{-4}
kg	ton (short)	1.102×10^{-3}
<i>Volume</i>		
m ³	cubic inch	6.102×10^4
m ³	cubic foot	35.315
m ³	gallon (U.S., liquid)	2.642×10^2
m ³	gallon (Imperial)	2.200×10^2
<i>Temperature</i>		
°C	°F	°C × 1.8 + 32
<i>Force</i>		
N	dyne	1.0×10^5
<i>Energy, Work</i>		
J	Btu (int.)	9.480×10^{-4}
J	cal (int.)	2.389×10^{-1}
J	eV	6.242×10^{18}
J	erg	1.0×10^7
J	kW·h	2.778×10^{-7}
J	kp·m	1.020×10^{-1}
<i>Pressure</i>		
MPa	at	10.20
MPa	atm	9.869
MPa	bar	10
kPa	mbar	10
kPa	mm Hg	7.502
kPa	psi	0.145
kPa	torr	7.502

Powers of Ten

E (exa)	10 ¹⁸	d (deci)	10 ⁻¹
P (peta)	10 ¹⁵	c (centi)	10 ⁻²
T (tera)	10 ¹²	m (milli)	10 ⁻³
G (giga)	10 ⁹	μ (micro)	10 ⁻⁶
M (mega)	10 ⁶	n (nano)	10 ⁻⁹
k (kilo)	10 ³	p (pico)	10 ⁻¹²
h (hecto)	10 ²	f (femto)	10 ⁻¹⁵
da (deca)	10	a (atto)	10 ⁻¹⁸

Abbreviations

The following is a list of the abbreviations used in the text. Common terms, the names of publications and institutions, and legal agreements are included along with their full identities. Other abbreviations will be defined wherever they first occur in an article. For further abbreviations, see page VII, Symbols and Units; page XIV, Frequently Cited Companies (Abbreviations), and page XV, Country Codes in patent references. The names of periodical publications are abbreviated exactly as done by Chemical Abstracts Service.

abs.	absolute	BGA	Bundesgesundheitsamt (Federal Republic of Germany)
a.c.	alternating current	BGB1.	Bundesgesetzblatt (Federal Republic of Germany)
ACGIH	American Conference of Governmental Industrial Hygienists	BIOS	British Intelligence Objectives Subcommittee Report (see also FIAT)
ACS	American Chemical Society	BOD	biological oxygen demand
ADI	acceptable daily intake	<i>bp</i>	boiling point
ADN	accord européen relatif au transport international des marchandises dangereuses par voie de navigation intérieure (European agreement concerning the international transportation of dangerous goods by inland waterways)	B.P.	British Pharmacopeia
ADNR	ADN par le Rhin (regulation concerning the transportation of dangerous goods on the Rhine and all national waterways of the countries concerned)	BS	British Standard
ADP	adenosine 5'-diphosphate	ca.	circa
ADR	accord européen relatif au transport international des marchandises dangereuses par route (European agreement concerning the international transportation of dangerous goods by road)	calcd.	calculated
AEC	Atomic Energy Commission (United States)	CAS	Chemical Abstracts Service
a.i.	active ingredient	cat.	catalyst, catalyzed
AICHe	American Institute of Chemical Engineers	CEN	Comité Européen de Normalisation
AIME	American Institute of Mining, Metallurgical, and Petroleum Engineers	cf.	compare
ANSI	American National Standards Institute	CFR	Code of Federal Regulations (United States)
AMP	adenosine 5'-monophosphate	cfu	colony forming units
APhA	American Pharmaceutical Association	Chap.	chapter
API	American Petroleum Institute	ChemG	Chemikaliengesetz (Federal Republic of Germany)
ASTM	American Society for Testing and Materials	C.I.	Colour Index
ATP	adenosine 5'-triphosphate	CIOS	Combined Intelligence Objectives Subcommittee Report (see also FIAT)
BAM	Bundesanstalt für Materialprüfung (Federal Republic of Germany)	CNS	central nervous system
BAT	Biologischer Arbeitsstofftoleranzwert (biological tolerance value for a working material, established by MAK Commission, see MAK)	Co.	Company
Beilstein	Beilstein's Handbook of Organic Chemistry, Springer, Berlin – Heidelberg – New York	COD	chemical oxygen demand
BET	Brunauer – Emmett – Teller	conc.	concentrated
		const.	constant
		Corp.	Corporation
		crit.	critical
		CTFA	The Cosmetic, Toiletry and Fragrance Association (United States)
		DAB	Deutsches Arzneibuch, Deutscher Apotheker-Verlag, Stuttgart
		d.c.	direct current
		decomp.	decompose, decomposition
		DFG	Deutsche Forschungsgemeinschaft (German Science Foundation)
		dil.	dilute, diluted
		DIN	Deutsche Industrienorm (Federal Republic of Germany)
		DMF	dimethylformamide
		DNA	deoxyribonucleic acid
		DOE	Department of Energy (United States)

DOT	Department of Transportation – Materials Transportation Bureau (United States)		gefährlicher Güter auf der Straße (regulation in the Federal Republic of Germany concerning the transportation of dangerous goods by road)
DTA	differential thermal analysis	GGVSee	Verordnung in der Bundesrepublik Deutschland über die Beförderung gefährlicher Güter mit Seeschiffen (regulation in the Federal Republic of Germany concerning the transportation of dangerous goods by sea-going vessels)
EC	effective concentration		
EC	European Community	GLC	gas-liquid chromatography
ed.	editor, edition, edited	Gmelin	Gmelin's Handbook of Inorganic Chemistry, 8th ed., Springer, Berlin – Heidelberg –New York
e.g.	for example		
emf	electromotive force	GRAS	generally recognized as safe
EmS	Emergency Schedule	Hal	halogen substituent (–F, –Cl, –Br, –I)
EN	European Standard (European Community)	Houben- Weyl	Methoden der organischen Chemie, 4th ed., Georg Thieme Verlag, Stuttgart
EPA	Environmental Protection Agency (United States)	HPLC	high performance liquid chromatography
EPR	electron paramagnetic resonance	IAEA	International Atomic Energy Agency
Eq.	equation	IARC	International Agency for Research on Cancer, Lyon, France
ESCA	electron spectroscopy for chemical analysis	IATA-DGR	International Air Transport Association, Dangerous Goods Regulations
esp.	especially	ICAO	International Civil Aviation Organization
ESR	electron spin resonance	i.e.	that is
Et	ethyl substituent (–C ₂ H ₅)	i.m.	intramuscular
et al.	and others	IMDG	International Maritime Dangerous Goods Code
etc.	et cetera	IMO	Inter-Governmental Maritime Consul- tive Organization (in the past: IMCO)
EVO	Eisenbahnverkehrsordnung (Federal Republic of Germany)	Inst.	Institute
exp (...)	e ^(...) , mathematical exponent	i.p.	intraperitoneal
FAO	Food and Agriculture Organization (United Nations)	IR	infrared
FDA	Food and Drug Administration (United States)	ISO	International Organization for Standardization
FD&C	Food, Drug and Cosmetic Act (United States)	IUPAC	International Union of Pure and Applied Chemistry
FHSA	Federal Hazardous Substances Act (United States)	i.v.	intravenous
FIAT	Field Information Agency, Technical (United States reports on the chemical industry in Germany, 1945)	Kirk- Othmer	Encyclopedia of Chemical Technology, 3rd ed., 1991–1998, 5th ed., 2004–2007, John Wiley & Sons, Hoboken
Fig.	figure	(1)	liquid
<i>fp</i>	freezing point	Landolt- Börnstein	Zahlenwerte u. Funktionen aus Physik, Chemie, Astronomie, Geophysik u. Technik, Springer, Heidelberg 1950– 1980; Zahlenwerte und Funktionen aus Naturwissenschaften und Technik, Neue Serie, Springer, Heidelberg, since 1961
Friedländer	P. Friedländer, Fortschritte der Teerfarbenfabrikation und verwandter Industriezweige Vol. 1–25, Springer, Berlin 1888–1942	LC ₅₀	lethal concentration for 50 % of the test animals
FT	Fourier transform	LCLo	lowest published lethal concentration
(g)	gas, gaseous		
GC	gas chromatography		
GefStoffV	Gefahrstoffverordnung (regulations in the Federal Republic of Germany con- cerning hazardous substances)		
GGVE	Verordnung in der Bundesrepublik Deutschland über die Beförderung gefährlicher Güter mit der Eisenbahn (regulation in the Federal Republic of Germany concerning the transportation of dangerous goods by rail)		
GGVS	Verordnung in der Bundesrepublik Deutschland über die Beförderung		

LD ₅₀	lethal dose for 50 % of the test animals	OSHA	Occupational Safety and Health Administration (United States)
LDLo	lowest published lethal dose	p., pp.	page, pages
ln	logarithm (base e)	Patty	G.D. Clayton, F.E. Clayton (eds.): Patty's Industrial Hygiene and Toxicology, 3rd ed., Wiley Interscience, New York
LNG	liquefied natural gas	PB	Publication Board Report (U.S. Department of Commerce, Scientific and Industrial Reports)
log	logarithm (base 10)	PEL	permitted exposure limit
LPG	liquefied petroleum gas	Ph	phenyl substituent ($-\text{C}_6\text{H}_5$)
M	mol/L	Ph. Eur.	European Pharmacopoeia, Council of Europe, Strasbourg
M	metal (in chemical formulas)	phr	part per hundred rubber (resin)
MAK	Maximale Arbeitsplatzkonzentration (maximum concentration at the workplace in the Federal Republic of Germany); cf. Deutsche Forschungsgemeinschaft (ed.): Maximale Arbeitsplatzkonzentrationen (MAK) und Biologische Arbeitsstofftoleranzwerte (BAT), WILEY-VCH Verlag, Weinheim (published annually)	PNS	peripheral nervous system
max.	maximum	ppm	parts per million
MCA	Manufacturing Chemists Association (United States)	q.v.	which see (quod vide)
Me	methyl substituent ($-\text{CH}_3$)	ref.	refer, reference
Methodicum Chimicum	Methodicum Chimicum, Georg Thieme Verlag, Stuttgart	resp.	respectively
MFAG	Medical First Aid Guide for Use in Accidents Involving Dangerous Goods	R_f	retention factor (TLC)
MIK	maximale Immissionskonzentration (maximum immission concentration)	R.H.	relative humidity
min.	minimum	RID	réglement international concernant le transport des marchandises dangereuses par chemin de fer (international convention concerning the transportation of dangerous goods by rail)
mp	melting point	RNA	ribonucleic acid
MS	mass spectrum, mass spectrometry	R phrase	risk phrase according to ChemG and GefStoffV (Federal Republic of Germany)
NAS	National Academy of Sciences (United States)	(R-Satz)	revisions per minute
NASA	National Aeronautics and Space Administration (United States)	rpm	Registry of Toxic Effects of Chemical Substances, edited by the National Institute of Occupational Safety and Health (United States)
NBS	National Bureau of Standards (United States)	RTECS	solid
NCTC	National Collection of Type Cultures (United States)	(s)	Society of Automotive Engineers (United States)
NIH	National Institutes of Health (United States)	SAE	subcutaneous
NIOSH	National Institute for Occupational Safety and Health (United States)	s.c.	International System of Units
NMR	nuclear magnetic resonance	SI	secondary ion mass spectrometry
no.	number	SIMS	safety phrase according to ChemG and GefStoffV (Federal Republic of Germany)
NOEL	no observed effect level	S phrase	Short Term Exposure Limit (see TLV)
NRC	Nuclear Regulatory Commission (United States)	(S-Satz)	standard temperature and pressure (0°C, 101.325 kPa)
NRDC	National Research Development Corporation (United States)	STEL	glass transition temperature
NSC	National Service Center (United States)	STP	Technische Anleitung zur Reinhaltung der Luft (clean air regulation in Federal Republic of Germany)
NSF	National Science Foundation (United States)	T_g	Technische Anleitung zum Schutz gegen Lärm (low noise regulation in Federal Republic of Germany)
NTSB	National Transportation Safety Board (United States)	TA Luft	lowest published toxic dose
OECD	Organization for Economic Cooperation and Development	TA Lärm	
		TDL ₀	

THF	tetrahydrofuran	UVV	Unfallverhütungsvorschriften der Berufsgenossenschaft (workplace safety regulations in the Federal Republic of Germany)
TLC	thin layer chromatography		
TLV	Threshold Limit Value (TWA and STEL); published annually by the American Conference of Governmental Industrial Hygienists (ACGIH), Cincinnati, Ohio	VbF	Verordnung in der Bundesrepublik Deutschland über die Errichtung und den Betrieb von Anlagen zur Lagerung, Abfüllung und Beförderung brennbarer Flüssigkeiten (regulation in the Federal Republic of Germany concerning the construction and operation of plants for storage, filling, and transportation of flammable liquids; classification according to the flash point of liquids, in accordance with the classification in the United States)
TOD	total oxygen demand		
TRK	Technische Richtkonzentration (lowest technically feasible level)		
TSCA	Toxic Substances Control Act (United States)	VDE	Verband Deutscher Elektroingenieure (Federal Republic of Germany)
TÜV	Technischer Überwachungsverein (Technical Control Board of the Federal Republic of Germany)	VDI	Verein Deutscher Ingenieure (Federal Republic of Germany)
TWA	Time Weighted Average	vol	volume
UBA	Umweltbundesamt (Federal Environmental Agency)	vol.	volume (of a series of books)
Ullmann	Ullmann's Encyclopedia of Industrial Chemistry, 6th ed., Wiley-VCH, Weinheim 2002; Ullmann's Encyclopedia of Industrial Chemistry, 5th ed., VCH Verlagsgesellschaft, Weinheim 1985–1996; Ullmanns Enzyklopädie der Technischen Chemie, 4th ed., Verlag Chemie, Weinheim 1972–1984; 3rd ed., Urban und Schwarzenberg, München 1951–1970	vs.	versus
		WGK	Wassergefährdungsklasse (water hazard class)
		WHO	World Health Organization (United Nations)
USAEC	United States Atomic Energy Commission	Winnacker-Küchler	Chemische Technologie, 4th ed., Carl Hanser Verlag, München, 1982–1986; Winnacker-Küchler, Chemische Technik: Prozesse und Produkte, Wiley-VCH, Weinheim, 2003–2006
USAN	United States Adopted Names		
USD	United States Dispensatory	wt	weight
USDA	United States Department of Agriculture	\$	U.S. dollar, unless otherwise stated
U.S.P.	United States Pharmacopeia		
UV	ultraviolet		

Frequently Cited Companies (Abbreviations)

Air Products	Air Products and Chemicals	IFP	Institut Français du Pétrole
Akzo	Algemene Koninklijke Zout Organon	INCO	International Nickel Company
Alcoa	Aluminum Company of America	3M	Minnesota Mining and Manufacturing Company
Allied	Allied Corporation	Mitsubishi Chemical	Mitsubishi Chemical Industries
Amer.	American Cyanamid Company	Monsanto	Monsanto Company
Cyanamid	BASF Aktiengesellschaft	Nippon Shokubai	Nippon Shokubai Kagaku Kogyo
BASF	Bayer AG	PCUK	Pechiney Ugine Kuhlmann
Bayer	British Petroleum Company	PPG	Pittsburg Plate Glass Industries
BP	Celanese Corporation	Searle	G.D. Searle & Company
Celanese	Daicel Chemical Industries	SKF	Smith Kline & French Laboratories
Daicel	Dainippon Ink and Chemicals Inc.	SNAM	Società Nazionale Metandotti
Dainippon	The Dow Chemical Company	Sohio	Standard Oil of Ohio
Dow Chemical	DSM Dutch Staats Mijnen	Stauffer	Stauffer Chemical Company
DSM	E.I. du Pont de Nemours & Company	Sumitomo	Sumitomo Chemical Company
Du Pont	Exxon Corporation	Toray	Toray Industries Inc.
Exxon	Food Machinery & Chemical Corporation	UCB	Union Chimique Belge
FMC	GAF General Aniline & Film Corporation	Union Carbide	Union Carbide Corporation
GAF	W.R. Grace & Company	UOP	Universal Oil Products Company
W.R. Grace	Hoechst Aktiengesellschaft	VEBA	Vereinigte Elektrizitäts- und Bergwerks-AG
Hoechst	International Business Machines Corporation	Wacker	Wacker Chemie GmbH
IBM	ICI Imperial Chemical Industries		

Country Codes

The following list contains a selection of standard country codes used in the patent references.

AT	Austria	IL	Israel
AU	Australia	IT	Italy
BE	Belgium	JP	Japan *
BG	Bulgaria	LU	Luxembourg
BR	Brazil	MA	Morocco
CA	Canada	NL	Netherlands *
CH	Switzerland	NO	Norway
CS	Czechoslovakia	NZ	New Zealand
DD	German Democratic Republic	PL	Poland
DE	Federal Republic of Germany (and Germany before 1949) *	PT	Portugal
DK	Denmark	SE	Sweden
ES	Spain	SU	Soviet Union
FI	Finland	US	United States of America
FR	France	YU	Yugoslavia
GB	United Kingdom	ZA	South Africa
GR	Greece	EP	European Patent Office *
HU	Hungary	WO	World Intellectual Property Organization
ID	Indonesia		

*For Europe, Federal Republic of Germany, Japan, and the Netherlands, the type of patent is specified: EP (patent), EP-A (application), DE (patent), DE-OS (Offenlegungsschrift), DE-AS (Auslegeschrift), JP (patent), JP-Kokai (Kokai tokkyo koho), NL (patent), and NL-A (application).

Periodic Table of Elements

element symbol, atomic number, and relative atomic mass (atomic weight)

1A "European" group designation and old IUPAC recommendation										0
1 group designation to 1986 IUPAC proposal										18
1A "American" group designation, also used by the Chemical Abstracts Service until the end of 1986										VIIIA
1	2A									
H	1	2								
1.0079	IIA									
3	4									
Li	Be									
6.941	9.0122									
11	12									
Na	Mg									
22.990	24.305									
19	20	21	22	23	24	25	26	27	28	29
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu
39.098	40.078	44.956	47.867	50.942	51.996	54.938	55.845	58.933	58.693	63.546
37	38	39	40	41	42	43	44	45	46	47
Rb	Sr	Y	Zr	Nb	Mo	Tc*	Ru	Rh	Pd	Ag
85.468	87.62	88.906	91.224	92.906	95.94	98.906	101.07	102.91	106.42	107.87
55	56									
Cs	Ba									
132.91	137.33									
87	88									
Fr*	Ra*									
223.02	226.03									

Volume Contents

Cereals	1	Chemometrics	385
Cerium Mischmetal, Cerium Alloys, and Cerium Compounds	41	Chemotherapeutics.....	411
Cesium and Cesium Compounds	57	Chitin and Chitosan	471
Characterization of a Classification or Separation Process	63	Chlorinated Benzenes and other Nucleus- Chlorinated Aromatic Hydrocarbons...	483
Charcoal	93	Chlorinated Paraffins	521
Cheese, Processed Cheese, and Whey	99	Chlorine	531
Chemical and Biochemical Sensors	109	Chlorine Oxides and Chlorine Oxygen Acids.....	623
Chemical Conservation of Stone Structures	223	Chloroacetaldehydes	685
Chemical Plant Design and Construction	249	Chloroacetic Acids	697
Chemical Plants: Performance Measurement of Processes.....	335	Chloroamines	713
Chemical Products: Safety Regulations	353	Chloroethanes and Chloroethylenes.....	719
		Chloroformic Esters.....	789

Cross References

Cetyl Alcohol → Fatty Alcohols	14	Chloric Acid → Chlorine Oxides and Chlorine Oxygen Acids	8
Chalks → Drawing and Writing Materials	11	Chlorinated Biphenyls → Chlorinated Benzenes and other Nucleus-Chlorinated Aromatic Hydrocarbons	8
Chelating Agents → Ethylenediaminetetraacetic Acid and Related Chelating Agents	13;	Chlorination → Chlorinated Paraffins	8
→ Nitrilotriacetic Acid	24	Chlorites → Chlorine Oxides and Chlorine Oxygen Acids	8
Chemical Grouting → Silicates	32	Chloroanilines → Aniline	3
Chemical Vapor Deposition (CVD) → Thin Films	36	Chlorobenzenes → Chlorinated Benzenes and other Nucleus-Chlorinated Aromatic Hydrocarbons	8
Chiral Compounds → Optically Active Compounds	25	Chlorobiphenyls → Chlorinated Benzenes and other Nucleus-Chlorinated Aromatic Hydrocarbons	8
Chloral → Chloroacetaldehydes	8	Chlorocarbons → Chloroethanes and Chloroethylenes	8; → Chloromethanes
Chlor-Alkali Electrolysis → Chlorine	8	→ Chloropropanes, Chlorobutanes, and Chlorobutenes	9
Chloramine T → Chloroamines	8	Chlorofluorocarbons → Fluorine Compounds, Organic	15
Chloramphenicol → Antibiotics, I. General	3	Chloroform → Chloromethanes	9
Chloranil → Benzoquinone	5		
Chlorates → Chlorine Oxides and Chlorine Oxygen Acids	8		

Volume Overview

- Vol. 1 Abrasion and Erosion *to* Air, 1. Emissions and Atmosphere
Vol. 2 Air, 2. Effects of Air Pollutants *to* Amines, Aromatic
Vol. 3 Amino Acids *to* Antiepileptics
Vol. 4 Antifreezes *to* Basic Principles of Chromatography
Vol. 5 Batteries *to* Biotechnology, 1. General
Vol. 6 Biotechnology, 2. Metabolic Engineering *to* Carbon, 5. Activated Carbon
Vol. 7 Carbon, 6. Carbon Black *to* Cereal Products
Vol. 8 Cereals *to* Chloroformic Esters
Vol. 9 Chlorohydrins *to* Concrete
Vol. 10 Confectionery *to* Cyano Compounds, Inorganic
Vol. 11 Cyanuric Acid and Cyanuric Chloride *to* Dyes, General Survey
Vol. 12 Ecology and Ecotoxicology, Fundamentals *to* Enzymes, 4. Non-food Application
Vol. 13 Enzymes, 5. Enzymes in Organic Synthesis *to* Explosives
Vol. 14 Fats and Fatty Oils *to* Filtration
Vol. 15 Fire Extinguishing Agents *to* Formaldehyde
Vol. 16 Formamides *to* Glass, 2. Production
Vol. 17 Glass, 3. Forming *to* High-Throughput Screening
Vol. 18 HIV and AIDS Therapeutics *to* Immunotherapy and Vaccines
Vol. 19 Inclusion Compounds *to* Iron, 3. Direct Reduction Processes
Vol. 20 Iron, 4. Smelting Reduction Processes *to* Leather
Vol. 21 Leather Imitates *to* Luminescent Materials
Vol. 22 Magnesium *to* Metals, Surface Treatment
Vol. 23 Methacrylic Acid and Derivatives *to* Natural Gas
Vol. 24 Nematicides *to* Nuclear Technology
Vol. 25 Nucleic Acids *to* Paints and Coatings, 2. Types
Vol. 26 Paints and Coatings, 3. Paint Systems *to* Phosphorus
Vol. 27 Phosphorus Compounds, Inorganic *to* Plastics, Additives
Vol. 28 Plastics, Analysis *to* Polyesters
Vol. 29 Polyethylene *to* Potassium Compounds
Vol. 30 Powder Metallurgy and Sintered Materials *to* Quasicrystals
Vol. 31 Quinoline and Isoquinoline *to* Rubber, 8. Synthesis by Polymer Modification
Vol. 32 Rubber, 9. Chemicals and Additives *to* Silicones
Vol. 33 Silk *to* Sorbic Acid
Vol. 34 Spasmolytics *to* Sulfones and Sulfoxides
Vol. 35 Sulfonic Acids, Aliphatic *to* Tellurium and Tellurium Compounds
Vol. 36 Temperature Measurement *to* Thyrotherapeutic Agents
Vol. 37 Tin, Tin Alloys, and Tin Compounds *to* Urea
Vol. 38 Urea Derivatives *to* Wastewater
Vol. 39 Water *to* Zirconium and Zirconium Compounds
Vol. 40 Index