

LabTools

Tables
for
laboratory
use

MERCK

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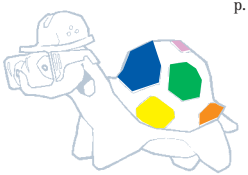
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Safety in the Laboratory
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SAFETY IN THE
LABORATORY

POISONS INFORMATION CENTRES

Several cities of the Federal Republic of Germany have poisons information centres. These centres, open to anybody, are on call day and night to give information over the phone about countermeasures to be taken in intoxication accidents of any type.

Austria
Vergiftungsinformationszentrale · Allgemeines Krankenhaus
Währinger Gürtel 18-20 · 1090 Wien
Telephone: (+43) (0)1 4 06 43 43
Languages: German, English, (French)

Belgium
Centre Antipoisons
c/o Hôpital Militaire Reine Astrid
Rue Bruyn · 1120 Bruxelles
Telephone: (+32) (070) 24 52 45
Languages: French, Flemish, English, (German)

Bulgaria
National Center of Clinical Toxicology Emergency
Medical Institute "Pirogov" · 1606 Sofia
Telephone: (+359) (0)2 5 15 32 34 / 34 09 / 35 46
Languages: Bulgarian, English, German, (French)

Czech Republic
Poison Information Centre
Clinic for Occupational Diseases
Vysehradska 49 · 12821 Prague 2
Telephone/Telefax: (+42) (0)2 29 38 68
Languages: Czech, English, German

Denmark
Poisons Information Centre
Rigshospitalet, 7122
Tagensvej 20 · 2200 Copenhagen Ø
Telephone: (+45) 35 45 35 45
Telefax: (+45) 35 45 73 49
Languages: Danish, English, (German)

Denmark
Arbejdsmiljøinstituttet · Produktregistret
Postbox 850
Lers Parkalle 105 · 2100 Copenhagen Ø
Telephone: (+45) 39 29 97 11
Telefax: (+45) 39 29 97 12
Languages: Danish

Finland
Poison Information Centre
Department of Clinical Pharmacology
University Central Hospital
Haartmaninkatu 4 · 00290 Helsinki
Telephone: (+358) (0)9 41 43 92
(+358) (0)9 47 11/27 88
Telefax: (+358) (0)9 4 71 47 02
Languages: Finnish, Swedish, English

France
Centre Anti-Poisons de Lille · C.H.R.
5 Avenue Oscar Lambret · 59037 Lille Cedex
Telephone: (+33) 03 20 44 44 44
Telefax: (+33) 03 20 44 56 28
Languages: French

France
Centre Anti-Poisons · Service de Pharmaco Toxicovigilance
et Centre Anti-Poisons · Hôpital Eduoard Herriot
5 Place d'Arsonval · 69003 Lyon
Telephone: (+33) (0)72 11 69 11
Telefax: (+33) (0)72 11 69 85
Languages: French

France
Centre Anti-Poisons de Marseille
Hôpital Salvator
249, bd Ste-Marguerite · 13009 Marseille
Telephone: (+33) 91/75 25 25
Telefax: (+33) 91/74 41 68
Languages: French, English, (Italian), (Spanish)

France
Centre Anti-Poisons de Nancy · Hôpital Central
29 Avenue Maréchal-de-Lattre-de-Tassigny
54035 Nancy Cedex
Telephone: (+33) 83 85 20 28
Telefax: (+33) 83 85 20 15
Languages: French

Greece
Poison Information Centre
Childrens Hospital "Aglaia Kyriakou" · 11527 Athens
Telephone: (+30) (0)1 7 79 37 77
Telefax: (+30) (0)1 7 48 61 14
Languages: Greek, English

Hungary
Department of Clinical Toxicology
Hospital Elizabeth
Alsoerdosor 7 · Budapest VII
Telephone: (+36) (0)1 21 52 15
Telefax: (+36) (0)1 22 94 60
Languages: Hungarian, German, English

Ireland
Poisons Information Centre
Royal Victoria Hospital
Grosvenor Road
Belfast BT 12 6BA
Northern Ireland
Telephone: (+44) (0) 12 32 24 05 03
Telefax: (+44) (0) 12 32 24 80 30
Languages: English

Ireland
Poisons Information Centre
Beaumont Hospital
P.O. Box 1297
Beaumont Road · Dublin 9
Republic of Ireland
Telephone: (+353) 0 10 35 31/8 37 99 64
Telefax: (+353) 0 10 35 31/8 37 69 82
Languages: English

Italy
Centro Antiveleni
Ospedale Niguarda "Ca Grande"
Piazza Ospedale Maggiore 3 · 20162 Milano
Telephone: (+39) (02) 66 10 10 29
Telefax: (+39) (02) 64 44 27 68
Languages: Italian, (French), (English)

Italy
Centro Antiveleni
Università di Floma
Policlinico Umberto I
Viale del Policlinico 155 · 00161 Roma
Telephone: (+39) (06) 49 06 63
Telefax: (+39) (06) 49 97 06 98
Languages: Italian, French, English

Italy
Centro Antiveleni
Università di Torino
Corso A.M Dogliotti, 14 · 10126 Torino
Telephone: (+39) (011) 6 63 76 37
Languages: Italian, French

Netherlands
Nationaal Vergiftingen
Informatie Centrum
Rijksinstiuut voor Volksgezondheid en Milieuhygiene
Antonie van Leewenhoeklaan 9
Postbus 1 · 3720 BA Blithoven
Telephone: (+31) (0)30 2 54 15 11
Telefax: (+31) (0)30 2 74 88 88
Languages: Dutch, (French), (English), (German)

POISONS INFORMATION CENTRES

Norway

Giftinformasjonssentralen
National Poison Information Centre
P.O. Box 8189 Dep. · 0034 Oslo 1
Telephone: (+47) (0)22 59 13 00
Telefax: (+47) (0)22 60 85 75
Languages: Norwegian, English

Poland

National Poison Information Centre and
Clinical Department of Toxicology Institute
of Occupational Medicine ul. Sw.
Teresy B, P.O. Box 199 · 90-950 Lodz
Telephone: (+48) (0)42 57 99 00
(+48) (0)42 57 42 95/
(+48) (0)42 31 47 24/25/52/67
Telefax: (+48) (0)42 34 83 31/55 61 02
Languages: Polish, English, German

Poland

Posion Centre of Warsaw
PL Weteranas 4 · 03-401 Warszawa
Telephone: (+48) (0)28 19 08 97
(+48) (0)28 19 66 54
Telefax: (+48) (0)28 19 69 43
Languages: Polish (24 h)
English (24 h)
(German) 8.00-14.00 h
(French) 8.00-14.00 h

Portugal

Centro de Informacao Antivenenos
Instituto Nacional de Emergencia Medica
Rua Infante D. Pedro, 8 · 1799 Lisboa Cedex
Telephone: (+351) (0)21 7 95 01 43
(+351) (0)21 7 95 01 44
)+351) (0)21 7 95 01 46
Telefax: (+351) (0)21 7 93 71 24
Languages: Portuguese, French, (English)

Rumania

Centre anti-Poisons
National Institute of Legal Medicine:
Sos. Vitan Birzesti 9, Sector 4 · 75669 Bucharest
Telephone: (+40) (0)1 6 34 38 90/1 35
Telefax: (+40) (0)1 3 21 02 60
Languages: Rumanian, French, English, German

Schweiz

Schweizerisches Toxikologisches Informationszentrum
Freiestr. 16 · CH-8028 Zürich
Telephone: (+41) (0)1 2 51 66 66
Telefax: (+41) (0)1 2 52 88 33
Languages: German, (English)

Slovakian Republic

Poison Information Centre
Clinic of Occupational Diseases
and Toxicology
Dumbierska 3 · 83101 Bratislava
Telephone: (+42) (7) 37 41 66
Telefax: (+42) (7) 37 46 05
Languages: Slovakian, German, English

Spain

Instituto Nacional de Toxicologia
Servicio Nacional de Informacion Toxicoligica
c/Mercé, 1 · 08002 Barcelona
Telephone: (+34) (3) 3 17 44 00
Telefax: (+34) (3) 3 18 25 30
Languages: Spanish

Spain

Servicio Nacional de Informacion
Toxicoligica · Instituto Nacional de Toxicologia
c/Luis Cabrera, 9 · 28002 Madrid
Telephone: (+34) (1) 5 63 69 24
Languages: Spanish, English

Spain

Instituto Nacional de Toxicologia
Servicio de Informacion Toxicoligica
ctra. San Jeronimo, Km 1,4
P.O. Box 863 · 41080 Sevilla
Telephone: (+34) (5)/4 37 12 33
Telefax: (+34) (5)/4 37 02 62
Languages: Spanish

Schweden

Giftinformationscentralen
Swedish Poisons Information Centre
17176 Stockholm
Telephone: (+46) (0)8 7 38 03 84
Telefax: (+46) (0)8 32 75 84
Languages: Swedish, English, (German)

United Kingdom

England
National Poisons Information Service
West Midlands Poisons Unit
City Hospital NHS Trust
Dudley Road · Birmingham B18 7QH
Telephone: (+44) (0)1 21 5 07 55 88/9
Telefax: (+44) (0)1 21 5 07 55 80
Languages: English

United Kingdom

England
Leeds Poisons Information Service
Pharmacy Department
The General Hospital
Great George Street · Leeds LS1 3EX
Telephone: (+44) (0)1 13 2 43 07 15
Telefax: (+44) (0)1 13 2 44 58 49
Languages: English

United Kingdom

England
National Poisons Information Service (L)
Medical Toxicology Unit
Avonley Road
London SE14 5ER
Telephone: (+44) (01 71) 6 35 91 91
Telefax: (+44) (01 71) 7 71 53 09
Languages: English

United Kingdom

England
Regional Drugs and Therapeutics Centre
Wolfson Unit
Claremont Place · Newcastle-upon-Tyne
Telephone: (+44) (0)1 91 2 32 15 25
(direct line, normal office hours)
(+44) (0)1 91 2 32 51 31
(24-hour service)
Telefax: (+44) (0)1 91 2 61 57 33
Languages: English

United Kingdom

Scotland
Scottish Poisons Information Bureau
The Royal Infirmary
Lauriston Place · Edinburgh EH3 9YW
Telephone: (+44) (0)1 31 5 36 22 98
Telefax: (+44) (0)1 31 5 36 23 04
Languages: English

United Kingdom

Wales
Welsh National Poisons Unit
Ward West 5 · Llandough Hospital Penarth
Cardiff CF6 1FF · South Glamorgan
Telephone: (+44) (0)12 22 70 99 01
Telefax: (+44) (0)12 22 70 43 57
Languages: English

PROPER CONDUCT IN THE LABORATORY



Chemistry is a fascinating thing for many beginners in related jobs.

Handling chemicals is, however, not only fascinating, but also risky, especially if processes are not performed adequately due to insufficient knowledge of the properties of the substances used. It is, therefore, absolutely necessary to inform oneself prior to its first use about any possible hazards involved in the handling of a certain chemical.

Every manufacurer of laboratory reagents is obliged to label these with the respective safety data. Should there be no reliable data on the toxicity of a preparation, Merck reagents are labeled with a corresponding warning note.

Laboratory chemicals are neither intended nor approved for use in humans or animals! Specifically tested pharmaceutical chemicals are available for such purpose.

The handling of hazardous chemicals demands special know-how, carefulness and adequate precautions. All tasks are to be performed such that hazardous gases, vapors or suspended particles are - as far as technically possible - not released.

If necessary, measures are to be taken to assure their uptake at the point of discharge/origin. When reaching the MAC specified in TRGS 900, special safety measures become necessary such as safe and practical personal protective gear. The following rules apply to provide safety during the working process:

1. When working in the laboratory or warehouse wear safety glasses and, where necessary, gloves.
2. In any case, avoid contact with skin, eyes and mucous membranes.
3. Rinse off any splashes on the skin with plenty of cold water; in the case of lipophilic substances rinse off with polyglycol. Due to the danger of absorption, never use other organic solvents.
4. Thoroughly rinse chemically burned eyes under a gentle stream of water or with a special eye shower. Rinse with your eyes wide open and roll your eyes in all directions. Subsequently, an ophthalmologic examination must be performed. It is absolutely necessary to inform the ophthalmologist of the chemical used. It is also recommended to state its hazardous properties in order to decide on adequate treatment.
5. Take off immediately any clothing contaminated with chemicals.
6. In case of accidents or if you feel unwell, consult a doctor and state the cause of accident including the name of the chemical involved.
7. Do not smoke, eat and drink in laboratory rooms.

What is a hazardous material?

In accordance with the German Chemicals Act (ChemG) such substances and preparations are classified hazardous materials that have toxic (acute and/or chronic) and/or dangerous physical-chemical and/or environmentally harmful properties.



NOTES ON HANDLING ETHERS AND OTHER PEROXIDE-FORMING SOLVENTS

Ether peroxides are generally known to be hazardous.

Some people still often underestimate the risk involved thus occasionally causing explosions when distilling off ethers. Such highly powerful explosions may also occur when containers filled with peroxide-containing liquids are shaken or when upon opening of a bottle the peroxide contained in the bottle neck is ignited by the resultant friction. These hazards apply not only to ethers but also to other liquids tending to form peroxides such as unsaturated hydrocarbons, aldehydes, ketones and tetralin. In order to prevent accidents, such liquids should be tested regularly for peroxides.



Determination of peroxides
1.10011 **Merckoquant® Peroxide Test**
Box with 100 strips
Ether peroxide can be easily and reliably detected and determined quantitatively with the test strips.

1.16206 **Perex Test®**
Information about the respective present peroxide content is the precondition for possibly quantitative and at the same time possibly economical elimination of peroxides. The methods described so far all have the same disadvantage of not being universally employable due to e. g. formation of 2 phases in aqueous reagents, no detection of polymeric peroxides, only qualitative results etc.

The Perex Test® provides a detection system for peroxides which fulfills the following demands:

- Detection of peroxides in aqueous and organic environments.
- Determination of peroxides in organic solvents in **one** phase.
- Detection of hydroperoxides and polymeric peroxides.
- Semiquantitative determination possible.

Not detectable: Dialkyl peroxides, dibenzoyl peroxides, peracid esters.

RISK (R) PHRASES:

R1	Explosive when dry.
R2	Risk of explosion by shock, friction, fire or other sources of ignition.
R3	Extreme risk of explosion by shock, friction, fire or other sources of ignition.
R4	Forms very sensitive explosive metallic compounds.
R5	Heating may cause an explosion.
R6	Explosive with or without air contact.
R7	May cause fire
R8	Contact with combustible material may cause fire.
R9	Explosive when mixed with combustible material.
R10	Flammable.
R11	Highly flammable.
R12	Extremely flammable.
R14	Reacts violently with water.
R15	Contact with water liberates extremely flammable gases.
R16	Explosive when mixed with oxidizing substances.
R17	Spontaneously flammable in air.
R18	In use, may form flammable/explosive vapour-air mixture.
R19	May form explosive peroxides.
R20	Harmful by inhalation.
R21	Harmful in contact with skin.
R22	Harmful if swallowed.
R23	Toxic by inhalation.
R24	Toxic in contact with skin.
R25	Toxic if swallowed.
R26	Very toxic by inhalation.
R27	Very toxic in contact with skin.
R28	Very toxic if swallowed.
R29	Contact with water liberates toxic gas.
R30	Can become highly flammable in use.
R31	Contact with acids liberates toxic gas.
R32	Contact with acids liberates very toxic gas.
R33	Danger of cumulative effects.
R34	Causes burns.
R35	Causes severe burns.
R36	Irritating to eyes.
R37	Irritating to respiratory system.
R38	Irritating to skin.
R39	Danger of very serious irreversible effects.
R40	Possible risk of irreversible effects.
R41	Risk of serious damage to eyes.
R42	May cause sensitization by inhalation.
R43	May cause sensitization by skin contact.
R44	Risk of explosion if heated under confinement.
R45	May cause cancer.
R46	May cause heritable genetic damage.
R48	Danger of serious damage to health by prolonged exposure.
R49	May cause cancer by inhalation.
R50	Very toxic to aquatic organisms.
R51	Toxic to aquatic organisms.
R52	Harmful to aquatic organisms.
R53	May cause long-term adverse effects in the aquatic environment.
R54	Toxic to flora.
R55	Toxic to fauna.
R56	Toxic to soil organisms.
R57	Toxic to bees.
R58	May cause long-term adverse effects in the environment.
R59	Dangerous for the ozone layer.
R60	May impair fertility.
R61	May cause harm to the unborn child.
R62	Possible risk of impaired fertility.
R63	Possible risk of harm to the unborn child.
R64	May cause harm to breastfed babies.
R65	Harmful: May cause lung damage if swallowed.
R66	Repeated exposure may cause skin dryness and dizziness.
R67	Vapours may cause tiredness and lightheadedness.
R68	Possible risks of irreversible effects.

COMBINATION OF RISK PHRASES:

R14/15	Reacts violently with water, liberating extremely flammable gases.
R15/29	Contact with water liberates toxic, highly flammable gas.
R20/21	Harmful by inhalation and in contact with skin.
R20/21/22	Harmful by inhalation, in contact with skin and if swallowed.
R20/22	Harmful by inhalation and if swallowed.
R21/22	Harmful in contact with skin and if swallowed.
R23/24	Toxic by inhalation and in contact with skin.
R23/24/25	Toxic by inhalation, in contact with skin and if swallowed.
R23/25	Toxic by inhalation and if swallowed.
R24/25	Toxic in contact with skin and if swallowed.
R26/27	Very toxic by inhalation and in contact with skin.
R26/27/28	Very toxic by inhalation, in contact with skin and if swallowed.
R26/28	Very toxic by inhalation and if swallowed.
R27/28	Very toxic in contact with skin and if swallowed.
R36/37	Irritating to eyes and respiratory system.
R36/37/38	Irritating to eyes, respiratory system and skin.
R36/38	Irritating to eyes and skin.
R68/20	Harmful: possible risk of irreversible effects through inhalation.
R68/20/21	Harmful: possible risk of irreversible effects through inhalation and in contact with skin.
R68/20/21/22	Harmful: possible risk of irreversible effects through inhalation, in contact with skin and if swallowed.
R68/20/22	Harmful: possible risk of irreversible effects through inhalation and if swallowed.
R68/21	Harmful: possible risk of irreversible effects in contact with skin.
R68/21/22	Harmful: possible risk of irreversible effects in contact with skin and if swallowed.
R68/22	Harmful: possible risk of irreversible effects if swallowed.

RISK (R) PHRASES:

R37/38	Irritating to respiratory system and skin.
R39/23	Toxic: danger of very serious irreversible effects through inhalation.
R39/23/24	Toxic: danger of very serious irreversible effects through inhalation and in contact with skin.
R39/23/25	Toxic: danger of very serious irreversible effects through inhalation and if swallowed.
R39/23/ 24/25	Toxic: danger of very serious irreversible effects effects through inhalation, in contact with skin and if swallowed.
R39/24	Toxic: danger of very serious irreversible effects in contact with skin.
R39/24/25	Toxic: danger of very serious irreversible effects in contact with skin and if swallowed.
R39/25	Toxic: danger of very serious irreversible effects if swallowed.
R39/26	Very toxic: danger of very serious irreversible effects through inhalation.
R39/26/27	Very toxic: danger of very serious irreversible effects through inhalation and in contact with skin.
R39/26/ 27/28	Very toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.
R39/26/28	Very toxic: danger of very serious irreversible effects through inhalation and if swallowed.
R39/27	Very toxic: danger of very serious irreversible effects in contact with skin.
R39/27/28	Very toxic: danger of very serious effects in contact with skin and if swallowed.
R39/28	Very toxic: danger of very serious irreversible effects if swallowed.
R40/20	Harmful: possible risk of irreversible effects through inhalation.
R40/20/21	Harmful: possible risk of irreversible effects through inhalation and in contact with skin.
R40/20/ 21/22	Harmful: possible risk of irreversible effects through inhalation, in contact with skin and if swallowed.
R40/20/22	Harmful: possible risk of irreversible effects through inhalation and if swallowed.
R40/21	Harmful: possible risk of irreversible effects in contact with skin.
R40/21/22	Harmful: possible risk of irreversible effects in contact with skin and if swallowed.
R40/22	Harmful: possible risk of irreversible effects if swallowed.
R42/43	May cause sensitization by inhalation and skin contact.
R48/20	Harmful: danger of serious damage to health by prolonged exposure through inhalation.
R48/20/21	Harmful: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin.
R48/20/ 21/22	Harmful: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.
R 48/20/22	Harmful: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.
R 48/21	Harmful: danger of serious damage to health by prolonged exposure in contact with skin.
R 48/21/22	Harmful: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed.
R 48/22	Harmful: danger of serious damage to health by prolonged exposure if swallowed.
R 48/23	Toxic: danger of serious damage to health by prolonged exposure through inhalation.
R 48/23/24	Toxic: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin.
R 48/23/ 24/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.
R 48/23/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.
R 48/24	Toxic: danger of serious damage to health by prolonged exposure in contact with skin.
R 48/24/25	Toxic: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed.
R 48/25	Toxic: danger of serious damage to health by prolonged exposure if swallowed.
R 50/53	Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
R 51/53	Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
R 52/53	Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

RISK PHRASES WITH SUPPLEMENTS

R E20	Also harmful by inhalation.
R E20/21	Also harmful by inhalation and in contact with skin.
R E20/21/22	Also harmful by inhalation, in contact with skin and if swallowed.
R E20/22	Also harmful by inhalation and if swallowed.
R E21	Also harmful in contact with skin.
R E21/22	Also harmful in contact with skin and if swallowed.
R E22	Also harmful if swallowed.
R E23	Also toxic by inhalation.
R E23/24	Also toxic by inhalation and in contact with skin.
R E23/24/25	Also toxic by inhalation, in contact with skin and if swallowed.

RISK (R) PHRASES:

R E23/25	Also toxic by inhalation and if swallowed.
R E24	Also toxic in contact with skin.
R E24/25	Also toxic in contact with skin and if swallowed.
R E25	Also toxic if swallowed.
R E26	Also very toxic by inhalation.
R E26/27	Also very toxic by inhalation and in contact with skin.
R E26/27/28	Also very toxic by inhalation, in contact with skin and if swallowed.
R E26/28	Also very toxic by inhalation and if swallowed.
R E27	Also very toxic in contact with skin.
R E27/28	Also very toxic in contact with skin and if swallowed. **R E28** Also very toxic if swallowed.
R E39/23	Also toxic: danger of very serious irreversible effects through inhalation.
R E39/23/24	Also toxic: danger of very serious irreversible effects through inhalation and in contact with skin.
R E39/23/ 24/25	Also toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.
R E39/23/25	Also toxic: danger of very serious irreversible effects through inhalation and if swallowed.
R E39/24	Also toxic: danger of very serious irreversible effects in contact with skin.
R E39/24/25	Also toxic: danger of very serious irreversible effects in contact with skin and if swallowed.
R E39/25	Also toxic: danger of very serious irreversible effects if swallowed.
R E39/26	Also very toxic: danger of very serious irreversible effects through inhalation.
R E39/26/27	Also very toxic: danger of very serious irreversible effects through inhalation and in contact with skin.
R E39/26/ 27/28	Also very toxic: danger of very serious irreversible effects through inhalation, in contact with skin and if swallowed.
R E39/26/28	Also very toxic: danger of very serious irreversible effects through inhalation and if swallowed.
R E39/27	Also very toxic: danger of very serious irreversible effects in contact with skin.
R E39/27/28	Also very toxic: danger of very serious irreversible effects in contact with skin and if swallowed.
R E39/28	Also very toxic: danger of very serious irreversible effects if swallowed.
R E40/20/21	Also harmful: possible risk of irreversible effects through inhalation and in contact with skin.
R E40/20/ 21/22	Also harmful: possible risk of irreversible effects through inhalation, in contact with skin and if swallowed.
R E40/20/22	Also harmful: possible risk of irreversible effects through inhalation and if swallowed.
R E40/21	Also harmful: possible risk of very serious irreversible effects in contact with skin.
R E40/21/22	Also harmful: possible risk of irreversible effects in contact with skin and if swallowed.
R E40/22	Also harmful: possible risk of irreversible effects if swallowed.
R E42/43	May cause sensitization by inhalation and skin contact.
R E48/20	Also harmful: danger of serious damage to health by prolonged exposure through inhalation.
R E48/20/21	Also harmful: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin.
R E48/20/ 21/22	Also harmful: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.
R E48/20/22	Also harmful: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.
R E48/21	Also harmful: danger of serious damage to health by prolonged exposure in contact with skin.
R E48/21/22	Also harmful: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed.
R E48/22	Also harmful: danger of serious damage to health by prolonged exposure if swallowed.
R E48/23	Also toxic: danger of serious damage to health by prolonged exposure through inhalation.
R E48/23/24	Also toxic: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin.
R E48/23/ 24/25	Also toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.
R E48/23/25	Also toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.
R E48/24	Also toxic: danger of serious damage to health by prolonged exposure in contact with skin.
R E48/24/25	Also harmful: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed.
R E48/25	Also toxic: danger of serious damage to health by prolonged exposure if swallowed.

SAFETY (S) PHRASES:

S 1	Keep locked up.
S 2	Keep out of reach of children.
S 3	Keep in a cool place.
S 4	Keep away from living quarters.
S 5	Keep contents under ...
S 6	Keep contents under ... (inert gas to be specified by the manufacturer).
S 6.1	Keep under nitrogen.
S 7	Keep container tightly closed.
S 8	Keep container dry.
S 9	Keep container in a well-ventilated place.
S 12	Do not keep the container sealed.
S 13	Keep away from food, drink and animal feeding stuffs.
S 14	Keep away from ...
S 14.1	Keep away from reducing agents, heavy metal compounds, acids and alkalis.
S 14.10	Keep away from acids, reducing agents and flammable material.
S 14.11	Keep away from flammable material.
S 14.2	Keep away from oxidizing and acidic substances as well as heavy metal compounds.
S 14.3	Keep away from iron.
S 14.4	Keep away from water and alkalis.
S 14.5	Keep away from acids.
S 14.6	Keep away from alkalis.
S 14.7	Keep away from metals.
S 14.8	Keep away from oxidizing and acidic substances.
S 14.9	Keep away from flammable organic substances.
S 15	Keep away from heat.
S 16	Keep away from sources of ignition - No smoking.
S 17	Keep away from combustible material.
S 18	Handle and open container with care.
S 20	When using do not eat or drink.
S 21	When using do not smoke.
S 22	Do not breathe dust.
S 23	Do not breathe gas/fumes/vapour/spray
S 23.1	Do not breathe gas.
S 23.2	Do not breathe vapour.
S 23.3	Do not breathe spray..
S 23.4	Do not breathe fumes.
S 23.5	Do not breathe fumes/spray.
S 24	Avoid contact with skin.
S 25	Avoid contact with eyes.
S 26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S 27	Take off immediately all contaminated clothing.
S 28	After contact with skin, wash immediately with plenty of ...
S 28.1	After contact with skin, wash immediately with plenty of water.
S 28.2	After contact with skin, wash immediately with plenty of soap and water.
S 28.3	After contact with skin, wash immediately with plenty of soap and water, if possible also with polyethylene glycol 400.
S 28.4	After contact with skin, wash immediately with plenty of polyethylene glycol 300 and ethanol (2:1) followed by plenty of soap and water.
S 28.5	After contact with skin, wash immediately with plenty of polyethylene glycol 400.
S 28.6	After contact with skin, wash immediately with plenty of polyethylene glycol 400, then rinse with plenty of water.
S 28.7	After contact with skin, wash immediately with plenty of water and acidic soap.
S 29	Do not empty into drains.
S 30	Never add water to this product.
S 33	Take precautionary measures against static discharges.
S 35	This material and its container must be disposed of in a safe way.
S 36	Wear suitable protective clothing.
S 37	Wear suitable gloves.
S 38	In case of insufficient ventilation, wear suitable respiratory equipment.
S 39	Wear eye/face protection.
S 40	To clean the floor and all objects contaminated by this material use ... (to be specified by the manufacturer).
S 41	In case of fire and/or explosion do not breathe fumes.
S 42	During fumigation/spraying with wear suitable respiratory equipment.
S 43	In case of fire, use ... (indicate the precise type of fire-fighting equipment. If water increases risk, add -'Never use water'.
S 43.1	In case of fire, use water.
S 43.2	In case of fire, use water or powder extinguisher.
S 43.3	In case of fire, use powder extinguisher. Never use water.
S 43.4	In case of fire, use CO2 - never use water.
S 43.6	In case of fire, use sand - never use water.
S 43.7	In case of fire, use metal fire powder - never use water.
S 43.8	In case of fire, use sand, CO2 or powder extinguisher, never use water.
S 45	In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
S 46	If swallowed, seek medical advice immediately and show this container or label.
S 47	Keep at temperature no exceeding ...°C (to be specified by the manufacturer).
S 47.1	Keep at temperature no exceeding 20°C.

SAFETY (S) PHRASES:

S 48	Keep wet with ... (appropriate material to be specified by the manufacturer).
S 49	Keep only in the original container.
S 50	Do not mix with ... (to be specified by the manufacturer).
S 50.1	Do not mix with acids.
S 50.2	Do not mix with alkalis.
S 50.3	Do not mix with strong acids, strong bases, non-ferrous metals or their salts.
S 51	Use only in well-ventilated areas.
S 52	Not recommended for interior use on large surface areas.
S 53	Avoid exposure - obtain special instructions before use. Restricted to professional users.
S 56	Dispose of this material and its container at hazardous or special waste collection point.
S 57	Use appropriate container to avoid environmental contamination!
S 59	Refer to manufacturer/supplier for information on recovery/recycling.
S 60	This material and its container must be disposed of as hazardous waste.
S 61	Avoid release to the environment. Refer to special instructions / Safety data sheet.
S 62	If swallowed, do not induce vomiting. Seek medical advice immediately and show this container or label.
S 63	In case of accident through inhalation: remove casually to fresh air and kept at rest.
S 64	In case of swallowed, rinse mouth with water (only if the person is conscious).

COMBINATION OF SAFETY PHRASES

S 1/2	Keep locked up and out of the reach of children.
S 3/7	Keep container tightly closed in a cool place.
S 3/9	Keep in a cool, well-ventilated place.
S 3/9/14	Keep in a cool, well-ventilated place away from .... (incompatible substances are to be specified by the manufacturer).
S 3/9/14.1	Keep in a cool, well-ventilated place away from reducing agents, heavy metal compounds, acids and alkalis.
S 3/9/14.2	Keep in a cool, well-ventilated place away from oxidizing agents and acidic substances as well as heavy metal compounds.
S 3/9/14.3	Keep in a cool, well-ventilated place away from iron.
S 3/9/14.4	Keep in a cool, well-ventilated place away from water and alkalis.
S 3/9/14.5	Keep in a cool, well-ventilated place away from acids.
S 3/9/14.6	Keep in a cool, well-ventilated place away from alkalis.
S 3/9/14.7	Keep in a cool, well-ventilated place away from metals.
S 3/9/14.8	Keep in a cool, well-ventilated place away from oxidizing and acidic substances.
S 3/9/14/49	Keep only in the original container in a cool, well-ventilated place away from ... (incompatible materials to be indicated by the manufacturer).
S 3/9/14.1/49	Keep in the original container in a cool, well-ventilated place away from reducing agents, heavy metal compounds, acids and alkalis.
S 3/9/14.2/49	Keep only in the original container in a cool, well-ventilated place away from oxidizing and acidic substances as well as heavy metal compounds.
S 3/9/14.3/49	Keep only in the original container in a cool, well-ventilated place away from iron.
S 3/9/14.4/49	Keep only in the original container in a cool, well-ventilated place away from water and alkalis.
S 3/9/14.5/49	Keep only in the original container in a cool, well-ventilated place away from acids.
S 3/9/14.6/49	Keep only in the original container in a cool, well-ventilated place away from alkalis.
S 3/9/14.7/49	Keep only in the original container in a cool, well-ventilated place away from metals.
S 3/9/14.8/49	Keep only in the original container in a cool, well-ventilated place away from oxidizing and acidic substances.
S 3/9/49	Keep only in the original container in a cool, well-ventilated place.
S 3/14	Keep in a cool place away from ... (incompatible materials to be indicated by the manufacturer).
S 3/14.1	Keep in a cool place away from reducing agents, heavy metal compounds, acids and alkalis.
S 3/14.2	Keep in a cool place away from oxidizing and acidic substances as well as heavy metal compounds.
S 3/14.3	Keep in a cool place away from iron.
S 3/14.4	Keep in a cool place away from water and alkalis.
S 3/14.5	Keep in a cool place away from acids.
S 3/14.6	Keep in a cool place away from alkalis.
S 3/14.7	Keep in a cool place away from metals.
S 3/14.8	Keep in a cool place away from oxidizing and acidic substances.

SAFETY (S) PHRASES:

S 7/8	Keep container tightly closed and dry.
S 7/9	Keep container tightly closed and in a well-ventilated place.
S 7/47	Keep container tightly closed and at temperature no exceeding ...°C (to be specified by the manufacturer).
S 20/21	When using do not eat, drink or smoke.
S 24/25	Avoid contact with skin and eyes.
S 27/28	After contact with skin, take off immediately all contaminated clothing and wash skin with plenty of ... (to be specified by the manufacturer).
S 29/56	Do not empty into drains; dispose of this material and its container at hazardous or special waste collection point.
S 36/37	Wear suitable protective clothing and gloves.
S 36/37/39	Wear suitable protective clothing, gloves and eye/face protection.
S 36/39	Wear suitable protective clothing and eye/face protection.
S 37/39	Wear suitable gloves and eye/face protection.
S 47/49	Keep only in the original container at temperature no exceeding ...°C (to be specified by the manufacturer).

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HAZARD SYMBOLS



E: Explosive
Criteria: Chemicals and preparations which may react exothermically without atmospheric oxygen and which under defined test conditions detonate, quickly deflagrate or upon heating explode when partially confined.
Precaution: Avoid impact, knocks, friction, sparks, fire, and heat.



O: Oxidizing.
Criteria: Organic peroxides which are combustible even if not in contact with combustible materials. Other chemicals and preparations which as a rule are not combustible themselves, but which in contact with combustible materials, mainly through oxygen evolution, considerably increase the fire hazard and the intensity of a fire.
Precaution: Avoid all contact with combustible substances.
Risk of ignition: The substance promotes fires once started and impedes fire fighting.



F: Highly flammable.
Criteria: Liquids with a flash point below 21 °C that are not extremely flammable. Solid substances and preparations which on brief exposure to a source of ignition may be easily inflamed and then continue to burn and smoulder.
Precaution: Keep away from naked flames, sparks, and sources of heat.



F+: Extremely flammable.
Criteria: Liquids with a flash point below 0 °C and a boiling point of max. 35 °C.
Gases and gas mixtures which are flammable in air at normal pressure and average temperatures.
Precaution: Keep away from naked flames, sparks, and sources of heat.



T: Toxic.
Criteria: Inhalation, swallowing, or absorption through the skin in small amounts can cause considerable damage to health, and may sometimes be lethal. In the event of serious evidence of severe, possibly irreversible damage to health by single, repeated, or prolonged absorption, especially carcinogenic, mutagenic, and reproduction-toxic effects.
Precaution: All contact with the human body must be avoided. If you feel unwell, seek medical advice immediately. Particular attention is drawn to the carcinogenic, teratogenic, or mutagenic risks associated with certain substances.
Observe special regulations when handling these substances!



T+: Very toxic.
Criteria: Inhalation, swallowing, or absorption through the skin in very small amounts can cause considerable damage to health, and may sometimes be lethal. In the event of serious evidence of severe, possibly irreversible damage to health by single, repeated, or prolonged absorption.
Criteria: All contact with the human body must be avoided. If you feel unwell, seek medical advice immediately.



C: Corrosive.
Criteria: Total damage to living tissues or when this result can be predicted.
Precaution: Take special measures to protect eyes, skin, and clothes. Do not inhale vapors! In case of accident or if you feel unwell, seek medical advice immediately.



Xn: Harmful.
Criteria: Inhalation, swallowing, or absorption through the skin can cause acute or chronic damage to health. In the event of evidence of severe, possibly irreversible damage to health by single, repeated, or prolonged absorption, especially in suspected carcinogenic, mutagenic, and reproduction-toxic effects.
Risk of sensitization by inhalation (classification with R42).
Precaution: All contact with the human body must be avoided. Particular attention is drawn to substances which are suspected to have a carcinogenic, mutagenic, or reproduction-toxic effect.



Xi: Irritating.
Criteria: Without being corrosive, immediate, prolonged, or repeated contact with skin or mucous membranes may cause inflammations. Risk of sensitization by skin contact (classification with R43).
Precaution: Avoid contact with eyes and skin, do not inhale vapors.



N: Dangerous for the environment.
Criteria: Liberation into the aquatic and non-aquatic environments can have an immediate or delayed detrimental effect upon the ecosystem through alteration of the natural balance.
Some substances or their conversion products may simultaneously affect various constituents of the ecosystem.
Precaution: Depending on the risk potential do not allow to enter sewerage systems. Observe special disposal regulations!

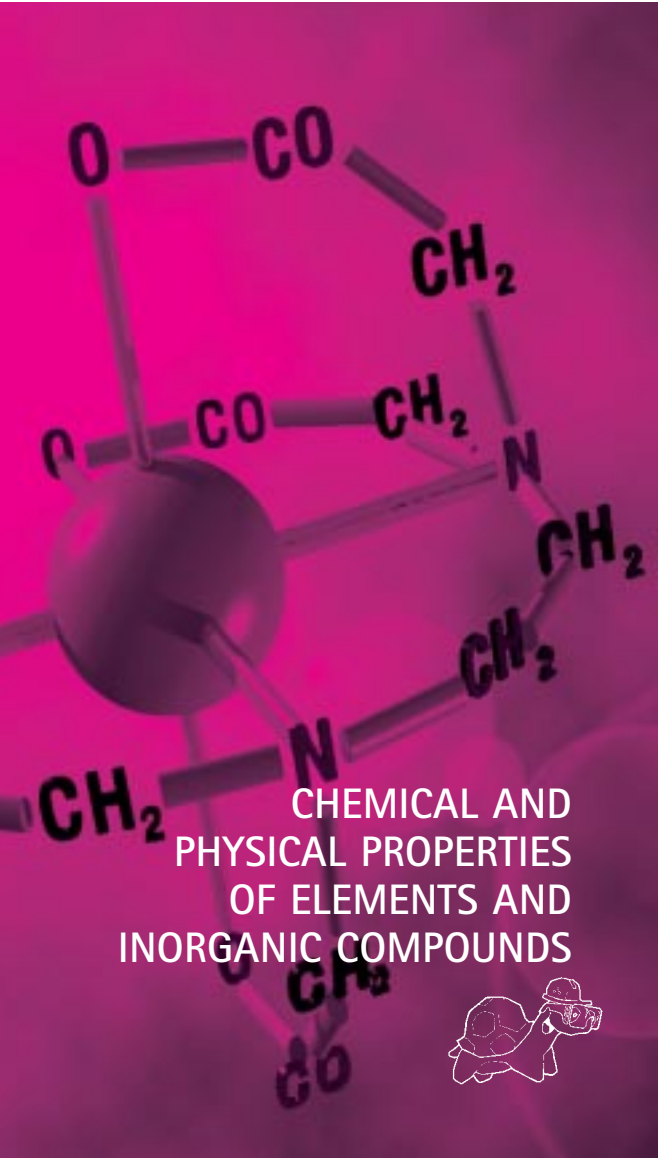
INCOMPATIBLE CHEMICALS

The chemicals listed below may react violently with one another. They must be kept apart and must never come into contact with one another. The objective of this list is to give information on how to avoid accidents in the laboratory.

Due to the great number of hazardous materials, this list includes only the most important examples.



Substance	Incompatible with
Acetylene	Chlorine, bromine, fluorine, copper, silver, mercury
Acetic acid	Chromium (VI) oxide, nitric acid, alcohols, ethylene glycol, perchloric acid, peroxides, permanganates
Activated carbon	Calcium hypochlorite, oxidizing agents
Alkali metals	Water, carbon tetrachloride and other halogenated alkanes, carbon dioxide, halogens
Aluminum alkyls	Water
Ammonia (laboratory gas or solutions)	Mercury (e.g. in pressure gauges), chlorine, calcium hypochlorite, iodine, bromine, hydrogen fluoride
Ammonium nitrate	Acids, powdered metals, flammable liquids, chlorates, nitrates, sulfur, fine-particulate organic or combustible materials
Aniline	Nitric acid, hydrogen peroxide
Bromine	See chlorine
Chlorine	Ammonia, acetylene, butadiene, butane, methane, propane, hydrogen, petroleum benzine, benzene, powdered metals
Chlorates	Ammonium salts, acids, powdered metals, sulfur, fine-particulate organic or combustible substances
Chromium (VI) oxide	Acetic acid, naphthalene, camphor, glycerol, petroleum benzine, alcohols, flammable liquids
Copper	Acetylene, hydrogen peroxide
Cumene hydroperoxide	Acids, both organic and inorganic
Cyanides	Acids
Flammable liquids	Ammonium nitrate, chromium (VI) oxide, hydrogen peroxide, nitric acid, sodium peroxide, halogens
Fluorine	Extremely aggressive; store separately!
Hydrocarbon (butane, propane, benzene etc.)	Fluorine, chlorine, bromine, chromium (VI) oxide, sodium peroxide
Hydrogen fluoride	Ammonia (laboratory gas or solutions)
Hydrogen peroxide	Copper, chromium, iron, metals and metal salts, alcohols, acetone, organic substances, aniline, nitromethane, combustible substances (solid or liquid)
Hydrogen sulfide	Fuming nitric acid, oxidizing gases
Iodine	Acetylene, ammonia (laboratory gas or solutions)
Mercury	Acetylene, ammonia
Nitric acid (concentrated)	Acetic acid, aniline, chromium (VI) oxide, prussic acid, hydrogen sulfide, flammable liquids and gases
Oxalic acid	Silver, mercury
Perchloric acid	Acetic anhydride, bismuth and its alloys, alcohols, paper, wood
Phosphorus	Sulfur, compounds containing oxygen, e.g. chlorates
Potassium	See alkali metals
Potassium chlorate	See chlorate
Potassium perchlorate	See chlorate
Potassium permanganate	Glycerol, ethylene glycol, benzaldehyde, sulfuric acid
Silver	Acetylene, oxalic acid, tartaric acid, ammonium compounds
Sodium	See alkali metals
Sodium peroxide	Methanol, ethanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerol, ethylene glycol, ethyl acetate, methyl acetate, furfural
Sulfuric acid	Potassium chorate, potassium perchlorate, potassium permangangate



CHEMICAL AND PHYSICAL PROPERTIES OF ELEMENTS AND INORGANIC COMPOUNDS

HARDNESS SCALE ACC. TO MOHS

Hardness	Mineral	Formula
1	Talcum	Mg_3 [$(OH)_2$ / Si_4O_{10}]
2	Gypsum	$CaSO_4 \cdot 2H_2O$
3	Calcite	$CaCO_3$
4	Fluorspar	CaF_2
5	Apatite	Ca_5 [(F, Cl, OH) / $(PO_4)_3$]
6	Feldspar	$KAlSi_3O_8$
7	Quartz	SiO_2
8	Topaz	Al_2 [F_2 / SiO_4]
9	Corundum	Al_2O_3
10	Diamond	C

ELECTROCHEMICAL SERIES OF THE ELEMENTS (ACIDIC SOLUTION)

ε° under standard conditions [25 °C, 10^5 Pa (1 bar)] measured against the hydrogen electrode as reference electrode

Red ⇄ Ox +e	e° (Volt)	Red ⇄ Ox +e	e° (Volt)
$Li \rightleftarrows Li^+ + 1e$	– 3.045	$Fe \rightleftarrows Fe^2 + 2e$	– 0.41
$Rb \rightleftarrows Rb^+ + 1e$	– 2.98	$Cd \rightleftarrows Cd^{2+} + 2e$	– 0.403
$Cs \rightleftarrows Cs^+ + 1e$	– 2.92	$Tl \rightleftarrows Tl^+ + 1e$	– 0.335
$K \rightleftarrows K^+ + 1e$	– 2.92	$Co \rightleftarrows Co^{2+} + 2e$	– 0.277
$Ba \rightleftarrows Ba^{2+} + 2e$	– 2.90	$Ni \rightleftarrows Ni^{2+} + 2e$	– 0.25
$Sr \rightleftarrows Sr^{2+} + 2e$	– 2.89	$Sn \rightleftarrows Sn^{2+} 2e$	– 0.136
$Ca \rightleftarrows Ca^{2+} + 2e$	– 2.866	$Pb \rightleftarrows Pb^{2+} + 2e$	– 0.126
$Na \rightleftarrows Na^+ + 1e$	– 2.713	$H_2 \rightleftarrows 2H^+ + 2e$	± 0.000
$Mg \rightleftarrows Mg^{2+} + 2e$	– 2.36	$Cu \rightleftarrows Cu^{2+} + 2e$	+ 0.337
$Be \rightleftarrows Be^{2+} + 2e$	– 1.85	$Cu \rightleftarrows Cu^+ + 1e$	+ 0.52
$Al \rightleftarrows Al^{3+} + 3e$	– 1.66	$Te \rightleftarrows Te^{4+} + 4e$	+ 0.56
$Mn \rightleftarrows Mn^{2+} + 2e$	– 1.18	$Ag \rightleftarrows Ag^+ + 1e$	+ 0.799
$Zn \rightleftarrows Zn^{2+} + 2e$	– 0.763	$Hg \rightleftarrows Hg^{2+} + 2e$	+ 0.854
$Cr \rightleftarrows Cr^{3+} + 3e$	– 0.744	$Pd \rightleftarrows Pd^{2+} + 2e$	+ 0.987
$Co \rightleftarrows Co^{3+} + 3e$	– 0.74	$Pt \rightleftarrows Pt^{2+} + 2e$	~ + 1.2
$Ga \rightleftarrows Ga^{3+} + 3e$	– 0.53	$Au \rightleftarrows Au^{3+} + 3e$	+ 1.498

TABLE OF ELEMENTS

Element name	Symbol	Ordinal-number	Atomic mass**	Density $D^{20°}_{4°}$	Melting-point [°C]	Boiling-point [°C]	Occurrence of the elements*** [%]	Atomic radiuses [pm]	Ionic radiuses [pm]	Electro-negativity
Actinium	Ac	89	227.028	10.1	1050	3200 ± 300	–	–	118 (III)	1.00
Aluminium	Al	13	26.98154	2.70	660.37	2467	8.1	143	51 (III)	1.47
Americium	Am	95	(243)	11.7	994 ± 4	2607	–	–	107 (III), 92 (IV)	~ 1.2
Antimony	Sb	51	121.76	6.68	630.74	1750	0.0001	145	76 (III), 62 (V)	1.82
Argon	Ar	18	39.948	*1.784	–189.2	–185.7	–	191	–	–
Arsenic	As	33	74.9216	5.73	817 (28 bar)	613 (sub.)	0.0005	125	58 (III), 46 (V)	2.20
Astatine	At	85	(210)	–	302	337	–	–	62 (VII)	1.96
Barium	Ba	56	137.33	3.7	725	1640	0.025	217	134 (II)	0.97
Berkelium	Bk	97	(247)	–	–	–	–	–	–	~ 1.2
Beryllium	Be	4	9.01218	1.86	1278 ± 5	2970 (5 mm)	0.0006	112	35 (II)	1.47
Bismuth	Bi	83	208.9804	9.80	271.3	1560 ± 5	0.00002	155	96 (III), 74 (V)	1.67
Boron	B	5	10.81	2.34	2300	2550 (sub.)	0.0003	97	23 (III)	2.01
Bromine	Br	35	79.904	3.14	–7.2	58.78	0.00016	119	196 (–I), 47 (V), 39 (VII)	2.74
Cadmium	Cd	48	112.41	8.64	320.9	765	0.000015	149	97 (II)	1.46
Cesium	Cs	55	132.9054	1.90	28.40 ± 0.01	678.4	0.0007	262	167 (I)	0.86
Calcium	Ca	20	40.078	1.55	839 ± 2	1484	3.6	196	99 (II)	1.04
Californium	Cf	98	(251)	–	–	–	–	–	–	~ 1.2
Carbon	C	6	12.011	2.25	~ 3550	4827	0.03	77	16 (IV)	2.50
Cerium	Ce	58	140.115	6.8	798 ± 3	3257	0.0046	182	107 (III), 94 (IV)	1.06
Chlorine	Cl	17	35.4527	*3.214	–100.98	–34.6	0.031	107	181 (–I), 34 (V), 27 (VII)	2.83
Chromium	Cr	24	51.996	7.19	1857 ± 20	2672	0.02	125	63 (III), 52 (VI)	1.56
Cobalt	Co	27	58. 9332	8.83	1495	2870	0.0023	125	72 (II), 63 (III)	1.70
Copper	Cu	29	63.546	8.93	1083.4 ± 0.2	2567	0.007	128	96 (I), 72 (II)	1.75
Curium	Cm	96	(247)	–	1340 ± 40	–	–	–	–	~ 1.2
Dysprosium	Dy	66	162.50	8.54	1409	2335	0.00045	–	92 (III)	1.10
Einsteinium	Es	99	(254)	–	–	–	–	–	–	~ 1.2
Erbium	Er	68	167.26	9.05	1522	2510	0.00025	–	89 (III)	1.11
Europium	Eu	63	151.96	5.26	822 ± 5	1597	0.00011	–	124 (II), 98 (III)	1.01
Fermium	Fm	100	(257)	–	–	–	–	–	–	~ 1.2
Fluorine	F	9	18.9984	*1.70	–219.62	–188.14	0.03	71	133 (–I), 8 (VII)	4.10
Francium	Fr	87	(223)	–	(27)	(677)	–	–	180 (I)	0.86
Gadolinium	Gd	64	157.25	7.90	1311 ± 1	3233	0.00064	–	97 (III)	1.11
Gallium	Ga	31	69.723	6.0	29.78	2403	0.0015	–	62 (III)	1.82
Germanium	Ge	32	72.61	5.36	937.4	2830	0.0007	–	73 (II), 53 (IV)	2.02
Gold	Au	79	196.966	19.3	1064.4	2807	0.00000005	144	137 (I), 85 (III)	1.42
Hafnium	Hf	72	178.49	13.3	2227 ± 20	4602	0.00045	–	78 (IV)	1.23
Helium	He	2	4.00260	*0.178	–272.2	–268.934	0.00000003	145	–	–
Holmium	Ho	67	164.93	8.80	1470	2720	0.00012	–	91 (III)	1.10
Hydrogen	H	1	1.00794	*0.0899	– 259.14	– 252.87	0.14	46	154 (–I)	2.20
Indium	In	49	114.82	7.31	156.61	2080	0.00001	–	81 (III)	1.49
Iod	I	53	126.9045	4.94	113.5	184.35	0.00003	136	220 (–), 62 (V), 50 (VII)	2.21
Iridium	Ir	77	192.22	22.6	2410	4130	0.00000001	–	68 (IV)	1.55
Iron	Fe	26	55.847	7.86	1535	2750	5.0	124	74 (II), 64 (III)	1.64
Krypton	Kr	36	83.80	*3.708	–156.6	–152(3)	–	–	–	–
Lanthanum	La	57	138.9055	6.1	920 ± 5	3454	0.0018	–	114 (III)	1.08
Lawrencium	Lr	103	(260)	–	–	–	–	–	–	–
Lead	Pb	82	207.2	11.4	327.5	1740	0.0016	175	215 (–II), 120 (II), 84 (IV)	1.55
Lithium	Li	3	6.941	0.53	180.54	1347	0.0065	152	68 (I)	0.97
Lutetium	Lu	71	174.967	9.84	1656 ± 5	3315	0.00008	–	85 (III)	1.14
Magnesium	Mg	12	24.305	1.74	648.8 ± 0,5	1090	0.21	160	66 (II)	1.23
Manganese	Mn	25	54.93805	7.3	1244 ± 3	1962	0.1	118	80 (II), 66 (III), 60 (IV), 46 (VII)	1.60

* Gases in [g/l] at °C and normal pressure ** longest-lived isotope in brackets *** Earth's crust

TABLE OF ELEMENTS

Element name	Symbol	Ordinal-number	Atomic mass**	Density D 20° 4°	Melting-point [°C]	Boiling-point [°C]	Occurrence of the elements*** [%]	Atomic radiuses [pm]	Ionic radiuses [pm]	Electro-negativity
Mendelevium	Md	101	(258)	–	–	–				~ 1.2
Mercury	Hg	80	200.59	13.55	– 38.87	356.58	0.00005	150	110 (II)	1.44
Molybdenum	Mo	42	95.94	10.2	2617	4612	0.0015	–	70 (IV), 62 (VI)	1.30
Neodymium	Nd	60	144.24	7.0	1010	3127	0.0024	–	104 (III)	1.07
Neon	Ne	10	20.1797	*0.90	– 248.7	– 246.05	–	–	–	–
Neptunium	Np	93	237.0482	19.5	640±1	3902	–	–	110 (III), 95 (IV), 71 (VII)	1.22
Nickel	Ni	28	58.69	8.90	1453	2732	0.008	124	69 (II)	1.75
Niobium	Nb	41	92.9064	8.5	2468 ± 10	4742	0.0024	–	74 (IV), 69 (VI)	1.23
Nitrogen	N	7	14.0067	*1.251	– 209.86	– 195.8	0.0046	71	16 (III), 13 (V)	3.07
Nobelium	No	102	(259)	–	–	–	–	–	–	–
Osmium	Os	76	190.23	22.5	3045 ± 30	5027±100	0.00000001	–	67 (IV), 69 (VI)	1.52
Oxygen	O	8	15.9994	*1.429	– 218.4	– 182.962	46.6	65	132 (–II), 10 (VI)	3.50
Palladium	Pd	46	106.42	12.0	1552	3140	0.0000001	–	80 (II), 65 (IV)	1.35
Phosphorous, white	P	15	30.97376	1.83	44.1	280	1.2	–	44 (III), 35 (V)	2.06
Platinum	Pt	78	195.08	21.45	1.772	3827	0.00000005	138	80 (II), 65 (IV)	1.44
Plutonium	Pu	94	(244)	19.7	641	3232	–	–	108 (III), 93 (IV)	1.22
Polonium	Po	84	(209)	9.32	254	962	–	–	–	1.76
Potassium	K	19	39.0983	0.86	63.65	774	2.6	231	133 (I)	0.91
Praseodymium	Pr	59	140.908	6.7	931 ± 4	3212	0.00055	–	106 (III), 92 (IV)	1.07
Promethium	Pm	61	(145)	–	~ 1080	–	–	–	106 (III)	1.07
Protactinium	Pa	91	231.036	–	< 1600	–	–	–	113 (III), 98 (IV), 89 (V)	1.14
Radium	Ra	88	226.0254	~6	700	1140	–	–	143 (II)	0.97
Radon	Rn	86	(222)	*9.96	– 71	– 61.8	–	–	–	–
Rhenium	Re	75	186.207	20.9	3180	–	0.00000001	–	72 (IV), 56 (VII)	1.46
Rhodium	Rh	45	102.905	12.4	1966 ± 3	3727±100	0.00000001	–	68 (III)	1.45
Rubidium	Rb	37	85.4678	1.53	38.89	688	0.03	243	147 (I)	0.89
Ruthenium	Ru	44	101.07	12.4	2310	3000	0.00000001	–	67 (IV)	1.42
Samarium	Sm	62	150.36	7.5	1072 ± 5	1778	0.00065	–	100 (III)	1.07
Scandium	Sc	21	44.9559	3.0	1539	2832	0.0005	–	81 (III)	1.20
Selenium	Se	34	78.96	4.8	217	684.9±1.0	0.000009	–	191 (–II), 83 (III), 50 (IV), 42 (VI)	2.48
Silver	Ag	47	107.8682	10.5	961.93	2212	0.00001	144	126 (I), 89 (II)	1.42
Silicium	Si	14	28.0855	2.4	1410	2355	27.7	117	221 (–IV), 42 (IV)	1.74
Sodium	Na	11	22.98977	0.97	97.81± 0.03	882.9	2.8	186	97 (I)	1.01
Strontium	Sr	38	87.62	2.6	769	1384	0.03	–	112 (II)	0.99
Sulphur	S	16	32.066	2.0	112.8	444.674	0.05	104	174 (–II), 37 (IV), 30 (VI)	2.44
Tantalum	Ta	73	180.9479	16.7	2996	5425±100	0.00021	–	68 (V)	1.33
Technetium	Tc	43	(97)	11.5	2172	4877	–	–	56 (VII)	1.36
Tellurium	Te	52	127.60	6.2	449.5 ± 0.3	989.8±3.8	0.00000002	–	211 (–II), 70 (IV), 56 (VI)	2.01
Terbium	Tb	65	158.92534	8.3	1360 ± 4	3041	0.00009	–	93 (III), 89 (IV)	1.10
Thallium	Tl	81	204.3833	11.85	303.5	1457±10	0.00006	–	147 (I), 95 (III)	1.44
Thorium	Th	90	232.0381	11.7	1750	ca. 4790	0.0012	–	102 (IV)	1.11
Thulium	Tm	69	168.9342	9.33	1545 ± 15	1727	0.00002	–	87 (III)	1.11
Tin	Sn	50	118.71	7.3	231.9681	2270	0.004	140	294 (–IV), 93 (II), 71 (IV)	1.72
Titanium	Ti	22	47.88	4.51	1660 ± 10	3287	0.45	–	80 (II), 76 (III), 68 (IV)	1.32
Tungston	W	74	183.84	19.30	3410 ± 20	5660	0.007	136	70 (IV), 62 (VI)	1.40
Uranium	U	92	238.029	19.1	1132.3±0.8	3818	0.0004	138	97 (IV), 80 (VI)	1.22
Vanadium	V	23	50.9415	6.1	1890 ± 10	3380	0.015	–	88 (II), 74 (III), 63 (IV), 59 (V)	1.45
Xenon	Xe	54	131.29	*5.89	– 111.9	– 107.1±3	–	–	–	–
Ytterbium	Yb	70	173.04	6.5	824 ± 5	1193	0.00027	–	86 (III)	1.06
Yttrium	Y	39	88.90585	4.5	1523 ± 8	3337	0.0028	–	92 (III)	1.11
Zinc	Zn	30	65.39	7.2	419.58	907	0.013	133	74 (II)	1.66
Zirkonium	Zr	40	91.224	6.5	1852 ± 2	4377	0.022	–	79 (IV)	1.22

* Gases in [g/l] at °C and normal pressure ** longest-lived isotope in brackets *** Earth's crust

ELECTROCHEMICAL SERIES OF SOME NONMETALS (ALKALINE SOLUTION)

Red $\rightleftarrows^{\circledR}$ Ox + e	e° (Volt)	Red $\rightleftarrows^{\circledR}$ Ox + e	e° (Volt)
$Te^{2-} \rightleftarrows Te + 2e$	– 1.14	$2\ I^- \rightleftarrows I_2 + 2e$	+ 0.54
$Se^{2-} \rightleftarrows Se + 2e$	– 0.92	$2\ Br^- \rightleftarrows Br_2 + 2e$	+ 1.07
$S^{2-} \rightleftarrows S + 2e$	– 0.48	$2\ Cl^- \rightleftarrows Cl_2 + 2e$	+ 1.36
		$2\ F^- \rightleftarrows F_2 + 2e$	+ 2.87

COVALENT SINGLE-BOND RADIUSES (IN PM)

H*	28	O	66
C	77	S	104
Si	117	Se	117
Ge	122	Te	137
Sn	140	F	64
N	70	Cl	99
P	110	Br	114
As	121	I	133
Sb	141		

* Determined from H-X bond distances



SOLUTIONS – AQUEOUS SYSTEMS

GENERAL FORMULAS FOR MIXING LIQUIDS

$$A = C - B \qquad B = \frac{C\,(a - c)}{a - b} \qquad C = B\,\frac{(a - b)}{a - c}$$

With:

A = weight of the original liquid
B = weight of the diluent
C = weight of the prepared mixture
For water as diluent: b = 0

a = its content in % by weight
b = its content in % by weight
c = its content in % by weight

Example:

10 l of battery sulfuric acid with a density of

$D^{20°}_{4°}$ = 1.28. 1.28 is required. Available: concentrated

sulfuric acid with a density of $D^{20°}_{4°}$ = 1.84 (= 97.5 weight%).

How much sulfuric acid and how much water are needed to prepare 10 l (= 12.8 kg) of battery sulfuric acid?

Calculation:

In the table 'Sulfuric acid' on page 52 we find:

$D^{20°}_{4°}$ = 1.28 equivalent to 37.36 weight%.

$$B = \frac{C\,(a - c)}{a - b} = \frac{12.80\,(97.50 - 37.36)}{97.50 - 0} = 7.895 \text{ kg diluent (water)}$$

Consequently, 4.905 kg (= 2.666 l) of concentrated sulfuric acid with a density of $D^{20°}_{4°}$ = 1.84 must be added to 7.895 kg (= l) of water to yield 10 l of battery acid with a density of $D^{20°}_{4°}$ = 1.28.

CONVERSION TABLE FOR WATER HARDNESS UNITS

	Alkaline earth ions mmol/l	Alkaline earth ions mval/l	German degree °d	ppm $CaCO_3$	English degree °e	French degree °f
1 mmol/l Alkaline earth ions	1.00	2.00	5.60	100.00	7.02	10.00
1 mval/l Alkaline earth ions	0.50	1.00	2.80	50.00	3.51	5.00
1 German degree	0.18	0.357	1.00	17.80	1.25	1.78
1 ppm $CaCO_3$	0.01	0.020	0.056	1.00	0.0702	0.10
1 English degree	0.14	0.285	0.798	14.30	1.00	1.43
1 French degree	0.10	0.200	0.560	10.00	0.702	1.00

MIXTURE RULE

Example:

Sulfuric acid with a density of $D^{20°}_{4°} = 1.520$ is to be prepared from sulfuric acid with a density of $D^{20°}_{4°} = 1.435$ and sulfuric acid of $D^{20°}_{4°} = 1.824$.



Calculation:

The table 'Sulfuric acid' (p. 52) informs that sulfuric acid with a density of $D^{20°}_{4°} = 1.435 = 54.00$ weight% H_2SO_4 contains sulfuric acid with a density of $D^{20°} = 1.824 = 92.00$ weight% H_2SO_4 and that of $D^{20°}_{4°} = 1.520 = 62.00$ weight% H_2SO_4.

From this, form the mixing cross:



i.e. 30 parts by weight of 54.00 % sulfuric acid must be mixed with 8 parts by weight of 92.00 % sulfuric acid to yield sulfuric acid of 62.00 weight% H_2SO_4, equivalent to $D^{20°}_{4°} = 1.520$.

PREPARATION OF DILUTE SOLUTIONS

Slowly stir the stated quantity of concentrated solution or solid KOH or NaOH, respectively, into water.

Caution: Strong development of heat may occur! Cool to room temperature, then make up to 1 liter with water. Store alkaline solutions in polyethylene bottles, because they attack glass.

As a rule of thumb, more concentrated solutions can be prepared by taking a multiple of the stated quantity.

Example:
6 mol/l HNO_3 from 6/2 x 140 ml = 420 ml 65 % HNO_3.

	Solution to be prepared			Original quantity to prepare 1 l of dilute solution	
	Weight%	Density	mol/l	Weight%	ml
Acetic acid	12	1.01	2	100	115
Nitric acid	12	1.07	2	65	140
Hydrochloric acid	7	1.03	2	36	165
Sulfuric acid	9.5	1.06	1	96	56
Ammonia	3.5	0.98	1	30	115
Potassium hydroxide solution	10.5	1.09	2	113 g solid KOH	(85%)
Sodium hydroxide solution	7.5	1.08	2	80 g solid NaOH	(100%)

Cat. No.	Name	Formula	Solubility in g/100 g H_2O at °C						Content of the total solution at 20 °C. in %	Density of the total solution at 20 °C. in %
			0	20	40	60	80	100		
1.01031	**A**luminum ammonium sulfate dodecahydrate	$AlNH_4(SO_4)_2 \cdot 12\ H_2O$	2.6	6.6	12.4	21.1	35.2	109.2 (95 °C)	6.2	1.0459 (15.5 °C)
1.01084	Aluminum chloride hexahydrate	$AlCl_3 \cdot 6H_2O$	44.9	45.6	46.3	47.7	47.7	–	31.3	–
1.01063	Aluminum nitrate nonahydrate	$Al(NO_3)_3 \cdot 9H_2O$	61.0	75.4	89.0	108.0	–	–	43.0	–
1.01047	Aluminum potassium sulfate dodecahydrate	$AlK(SO_4)_2 \cdot 12H_2O$	2.96	6.01	13.6	33.3	72.0	109.0 (90 °C)	5.67	1.053
1.01102	Aluminum sulfate octadecahydrate	$Al_2(SO_4)_3 \cdot 18H_2O$	31.2	36.4	45.6	58.0	73.0	89.0	26.7	1.308
1.01125	Ammonium bromide	NH_4Br	60.6	75.5	91.1	107.8	126.7	145.6	43.9	–
1.01145	Ammonium chloride	NH_4Cl	29.7	37.6	46.0	55.3	65.6	77.3	27.3	1.075
1.01126	Ammonium dihydrogen phosphate	$NH_4H_2PO_4$	22.7	36.8	56.7	82.9	120.7	174.0	26.9	–
1.01131	Ammonium hydrogen carbonate	NH_4HCO_3	11.9	21.2	36.6	59.2	109.2	355.0	17.5	1.07
1.01207	di-Ammonium hydrogen phosphate	$(NH_4)_2HPO_4$	57.5	68.6	81.8	97.6	(115.5)	–	40.70	1.3436 (14.5 °C)
1.01173	Ammonium iodide	$NH_4\ I$	154.2	172.3	190.5	208.9	228.8	250.3	63.3	–
1.03792	Ammonium iron(II) sulfate hexahydrate	$(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$	17.8	26.9	38.5	53.4	72.0	–	21.2	1.18
1.01226	Ammonium monovanadate	NH_4VO_3	–	4.8	13.2	–	–	–	–	–
1.01188	Ammonium nitrate	NH_4NO_3	118.5	187.7	283.0	415.0	610.0	1000.0	65.0	1.308
1.01217	Ammonium sulfate	$(NH_4)_2SO_4$	70.4	75.4	81.2	87.4	94.1	102.0	43.0	1.247
1.01213	Ammonium thiocyanate	NH_4SCN	115.0	163.0	235.0	347.0	–	–	62.0	–
1.07838	Antimony(III) chloride	$SbCl_3$	601.6	931.5	1368.0	4531.0	–	–	90.3	–
1.01704	**B**arium acetate	$Ba(CH_3COO)_2$	58.0	72.0	79.0	74.0	74.0	74.0	–	–
1.01719	Barium chloride dihydrate	$BaCl_2 \cdot 2H_2O$	30.7	35.7	40.8	46.4	52.5	58.7	26.3	1.28
1.01737	Barium hydroxide octahydrate	$Ba(OH)_2 \cdot 8H_2O$	1.5	3.5	8.2	21.0	–	–	3.4	1.04
1.01729	Barium nitrate	$Ba(NO_3)_2$	5.0	9.1	14.4	20.3	27.2	34.2	8.3	1.069
1.00163	di-Boron trioxide	B_2O_3	1.1	2.2	4.0	6.2	9.5	15.7	2.15	–
1.00165	Boric acid	H_3BO_3	2.7	5.04	8.7	14.8	23.6	39.7	4.8	1.015
1.02019	**C**admium nitrate tetrahydrate	$Cd(NO_3)_2 \cdot 4H_2O$	–	153.0	199.0	–	–	–	60.5	–
1.02027	Cadmium sulfate hydrate	$3CdSO_4 \cdot 8H_2O$	75.5	76.7	79.3	82.0	84.6	–	43.4	1.616
1.09325	Calcium acetate	$Ca(CH_3COO)_2$	37.4	34.7	33.2	32.7	33.5	29.7	–	–
1.02382	Calcium chloride dihydrate	$CaCl_2 \cdot 2H_2O$	–	–	128.1	136.8	147.0	159.0	–	–
1.02121	Calcium nitrate tetrahydrate	$Ca(NO_3)_2 \cdot 4H_2O$	101.0	129.4	196.0	–	–	–	56.4	–
1.02161	Calcium sulfate dihydrate	$CaSO_4 \cdot 2H_2O$	0.18	0.20	0.21	0.20	0.19	0.16	0.20	1.001
1.02038	Cesium chloride	$CsCl$	161.0	187.0	208.0	230.0	250.0	271.0	–	–
1.02856	Cesium nitrate	$CsNO_3$	9.3	23.0	47.2	83.8	134.0	197.0	–	–
1.00229	Chromium(VI) oxide	CrO_3	163.0	166.7	171.0	176.0	189.0	199.0	62.50	1.7100 (16.5 °C)
8.02540	Cobalt chloride	$CoCl_2$	74.5	91.9	–	–	–	–	47.9	1.52
1.02539	Cobalt chloride hexahydrate	$CoCl_2 \cdot 6H_2O$	–	62.35	68.6	78.3	–	–	38.4	1.49
1.02536	Cobalt nitrate hexahydrate	$Co(NO_3)_2 \cdot 6H_2O$	–	–	–	–	525.1	537.0	–	–
1.02556	Cobalt sulfate heptahydrate	$CoSO_4 \cdot 7H_2O$	41.9	53.6	69.5	–	–	–	34.9	–
1.02739	Copper(I) chloride	$CuCl$	–	1.5 (25 °C)	–	–	–	–	1,497 (25 °C)	–
1.02733	Copper(II) chloride dihydrate	$CuCl_2 \cdot 2H_2O$	70.65	77.0	83.8	91.2	99.2	107.9	43.5	1. 55
1.02753	Copper(II) nitrate trihydrate	$Cu(NO_3)_2 \cdot 3H_2O$	–	–	160.0	179.0	208.0	(257.0)	–	–
1.02790	Copper(II) sulfate pentahydrate	$CuSO_4 \cdot 5H_2O$	14.8	20.8	29.0	39.1	53.6	73.6	17.2	1.1965
1.02791	Copper sulfate	$CuSO_4$	25.5	36.2	48.0	60.0	70.0	83.0	–	–
8.03945	**I**ron(III) chloride	$FeCl_3$	25.5	36.3	49.9	–	–	–	26.6	–
1.03943	Iron(III) chloride hexahydrate	$FeCl_3 \cdot 6H_2O$	83.5	100.0	126.0	169.5	–	–	50.0	–

SOLUBILITY OF INORGANIC COMPOUNDS IN WATER IN RELATION TO TEMPERATURE

Cat. No.	Name	Formula	Solubility in g/100 g H_2O at °C						Content of the total solution at 20 °C. in %	Density of the total solution at 20 °C. in %
			0	20	40	60	80	100		
1.03861	Iron(II) chloride tetrahydrate	$FeCl_2 \cdot 4H_2O$	–	–	–	(90.5) (56 °C)	100.0	107.5	–	–
1.03965	Iron(II) sulfate heptahydrate	$FeSO_4 \cdot 7H_2O$	15.6	26.6	40.3	47.6	–	–	21.0	1.225
1.03967	Iron(II) sulfate monohydrate	$FeSO_4 \cdot H_2O$	–	–	–	–	43.8	(31.6)	–	–
8.07383	Lead chloride	$PbCl_2$	0.67	0.99	1.45	1.98	2.6	3.3	0.98	1.007
1.07398	Lead nitrate	$Pb(NO_3)_2$	36.4	52.2	69.4	88.0	107.5	127.3	34.3	1.40
1.05669	Lithium bromide	LiBr	143.0	177.0	205.0	224.0	245.0	266.0	–	–
1.05680	Lithium carbonate	Li_2CO_3	–	1.3	–	–	–	–	1.31	–
1.05677	Lithium chloride monohydrate	$LiCl \cdot H_2O$	–	82.8	90.4	100.0	113.0	(127.5)	45.3	1.29
1.11652	Lithium hydroxide monohydrate	$LiOH \cdot H_2O$	12.0	12.4	–	13.4	14.9	17.9	11.0	–
8.18287	Lithium iodide	LiI	151.0	165.0	180.0	–	–	480.0	–	–
1.12230	Lithium nitrate	$LiNO_3$	48.0	76.0	–	–	–	227.0	–	–
1.05694	Lithium sulfate monohydrate	$LiSO_4 \cdot H_2O$	36.2	34.8	33.5	32.3	31.5	31.0	25.6	1.23
1.05833	Magnesium chloride hexahydrate	$MgCl_2 \cdot 6H_2O$	52.8	54.6	57.5	60.7	65.9	72.7	35.3	1.331
1.05853	Magnesium nitrate hexahydrate	$Mg(NO_3)_2 \cdot 6H_2O$	63.9	70.1	81.8	93.7	–	–	41.2	1.388 (25 °C)
1.05886	Magnesium sulfate heptahydrate	$MgSO_4 \cdot 7H_2O$	–	35.6	45.4	–	–	–	26.25	1.31
1.05927	Manganese(II) chloride tetrahydrate	$MnCl_2 \cdot 4H_2O$	63.6	73.6	88.7	(106.0) (58.1°C)	–	–	42.4	1.499
1.05934	Manganese(II) chloride dihydrate	$MnCl_2 \cdot 2H_2O$	–	–	–	–	110.5	115.0	–	–
1.05941	Manganese(II) sulfate monohydrate	$MnSO_4 \cdot H_2O$	–	–	60.0	58.6	45.5	35.5	–	–
1.04421	Mercury(II) bromide	$HgBr_2$	–	0.62 (25 °C)	(0.96)	1.7	2.8	4.9	0.62 (25 °C)	–
1.04419	Mercury(II) chloride	$HgCl_2$	4.29	6.6	9.6	13.9	24.2	54.1	6.2	1.052
1.06717	Nickel chloride hexahydrate	$NiCl_2 \cdot 6H_2O$	51.7	55.3	–	–	–	–	35.6	1.46
1.06721	Nickel nitrate hexahydrate	$Ni(NO_3)_2 \cdot 6H_2O$	79.2	94.1	118.8	–	–	–	48.5	–
1.06727	Nickel sulfate hexahydrate	$Ni_2SO_4 \cdot 6H_2O$	–	–	–	57.0	–	–	–	–
1.04820	Potassium acetate	KCH_3COO	217.0	256.0	323.0	350.0	–	380.0	–	–
1.04912	Potassium bromate	$KBrO_3$	3.1	6.8	13.1	22.0	33.9	49.7	6.4	1.048
1.04905	Potassium bromide	KBr	54.0	65.8	76.1	85.9	95.3	104.9	39.7	1.370
1.04928	Potassium carbonate	K_2CO_3	106.0	110.0	117.0	127.0	140.0	156.0	–	–
1.04944	Potassium chlorate	$KClO_3$	3.3	7.3	14.5	25.9	39.7	56.2	6.8	1.042
1.04936	Potassium chloride	KCl	28.2	34.2	40.3	45.6	51.0	56.2	25.5	1.174
1.04952	Potassium chromate	K_2CrO_4	59.0	63.7	67.0	70.9	75.1	79.2	38.9	1.378
1.04967	Potassium cyanide	KCN	(63.0)	71.6 (25 °C)	–	81.0 (50 °C)	(95.0) (75 °C)	122.0 (103.3 °C)	41.73 (25 °C)	–
1.04864	Potassium dichromate	$K_2Cr_2O_7$	4.7	12.5	26.3	45.6	73.0	103.0	11.1	1.077
1.04873	Potassium dihydrogen phosphate	KH_2PO_4	14.3	22.7	33.9	48.6	68.0	–	18.5	–
1.05057	Potassium disulfite	$K_2S_2O_5$	27.5	44.9	63.9	85.0	108.0	133.0	30.99	–
1.19238	Potassium hexachloroplatinate(IV)	$K_2[Pt(Cl)_6]$	0.74	1.1	1.7	2.6	3.8	5.2	–	–
1.04984	Potassium hexacyanoferrate(II) trihydrate	$K_4[Fe(CN)_6] \cdot 3H_2O$	15.0	28.9	42.7	56.0	68.9	(82.7)	22.4	1.16
1.04973	Potassium hexacyanoferrate(III)	$K_3[Fe(CN)_6]$	29.9	46.0	59.5	70.9	81.8	91.6	31.5	1.18
1.04854	Potassium hydrogen carbonate	$KHCO_3$	22.6	33.3	45.3	60.0	–	–	24.98	1.18
1.05099	di-Potassium hydrogen phosphate trihydrate	$K_2HPO_4 \cdot 3H_2O$	–	159.0	212.5	– (50 °C)	– (75 °C)	–	61.4	–
1.05104	di-Potassium hydrogen phosphate	K_2HPO_4	–	–	–	266.0	–	–	–	–
1.04885	Potassium hydrogen sulfate	$KHSO_4$	36.3	51.4	67.3	–	–	121.6	33.95	–
1.05002	Potassium hydroxide monohydrate	$KOH \cdot H_2O$	–	–	136.4	147.0	160.0	178.0	–	–

Cat. No.	Name	Formula	Solubility in g/100 g H_2O at °C						Content of the total solution at 20 °C. in %	Density of the total solution at 20 °C. in %
			0	20	40	60	80	100		
1.05051	Potassium iodate	KIO_3	4.7	8.1	12.9	18.5	24.8	32.3	7.5	1.064
1.05043	Potassium iodide	KI	127.8	144.5	161.0	176.2	191.5	208.0	59.1	1.71
1.05063	Potassium nitrate	KNO_3	13.3	31.7	63.9	109.9	169.0	245.2	24.1	1.16
1.05073	di-Potassium oxalate monohydrate	$K_2C_2O_4 \cdot H_2O$	–	35.9	–	–	–	–	26.4	–
1.05076	Potassium perchlorate	$KClO_4$	0.76	1.7	3.6	7.2	13.4	22.2	1.7	1.008
1.05079	Potassium periodate	KIO_4	0.17	0.4	0.9	2.2	4.4	7.9	0.418	–
1.05082	Potassium permanganate	$KMnO_4$	2.8	6.4	12.6	22.4	–	–	6.0	1.04
1.05091	Potassium peroxodisulfate	$K_2S_2O_8$	0.18	0.5	1.1	–	–	–	0.468	–
1.05153	Potassium sulfate	K_2SO_4	7.3	11.1	14.8	18.2	21.3	24.1	10.0	1.0807
1.05125	Potassium thiocyanate	KSCN	177.0	218.0	–	–	–	–	68.55	1.42
1.07615	**R**ubidium chloride	RbCl	70.6	83.6	–	–	–	128.0	–	–
1.06267	**S**odium acetate trihydrate	$NaCH_3COO \cdot 3H_2O$	36.3	46.4	65.4	138.0 (58°C)	–	–	31.7	1.17
1.06363	Sodium bromide	NaBr	–	–	–	118.0	118.3	121.2	–	–
1.06391	Sodium carbonate decahydrate	$Na_2CO_3 \cdot 10H_2O$	6.86	21.7	–	–	–	–	17.8	1.1941
1.06386	Sodium carbonate monohydrate	$Na_2CO_3 \cdot H_2O$	–	–	48.9	46.2	44.5	44.5	–	–
1.06392	Sodium carbonate	Na_2CO_3	7.1	21.4	48.5	46.5	45.8	45.5	–	–
1.06423	Sodium chlorate	$NaClO_3$	80.5	98.8	115.2	(138.0)	(167.0)	204.0	49.7	–
1.06404	Sodium chloride	NaCl	–	35.9	36.4	37.1	38.1	39.2	26.4	1.201
1.06425	Sodium chromate tetrahydrate	$Na_2CrO_4 \cdot 4H_2O$	–	–	95.3	115.1	–	–	–	–
1.06427	Sodium chromate	Na_2CrO_4	–	–	–	–	124.0	125.9	–	–
1.06336	Sodium dichromate dihydrate	$Na_2Cr_2O_7 \cdot 2H_2O$	163.2	180.2	220.5	283.0	385.0	–	64.3	–
1.06345	Sodium dihydrogen phosphate dihydrate	$NaH_2PO_4 \cdot 2H_2O$	57.7	85.2	138.2	–	–	–	46.0	–
1.06370	Sodium dihydrogen phosphate	NaH_2PO_4	–	–	–	179.3	207.3	284.4	–	–
1.06591	tetra-Sodium diphosphate decahydrate	$Na_4P_2O_7 \cdot 10H_2O$	2.7	5.5	12.5	21.9	30.0	40.3	5.2	1.05
1.06528	Sodium disulfite	$Na_2S_2O_5$	–	65.3	71.1	79.9	88.7	(100.0)	39.5	–
1.06449	Sodium fluoride	NaF	(3.6)	4.1	–	–	–	–	3.94	1.04
1.06329	Sodium hydrogen carbonate	$NaHCO_3$	6.89	9.6	12.7	16.0	19.7	23.6	8.76	1.08
1.06579	di-Sodium hydrogen phosphate dodecahydrate	$Na_2HPO_4 \cdot 12H_2O$	1.63	7.7	–	–	–	–	7.2	1.08
1.06575	di-Sodium hydrogen phosphate heptahydrate	$Na_2HPO_4 \cdot 7H_2O$	–	–	55.0	–	–	–	–	–
1.06580	di-Sodium hydrogen phosphate dihydrate	$Na_2HPO_4 \cdot 2H_2O$	–	–	–	83.0	92.4	–	–	–
1.06586	di-Sodium hydrogen phosphate	Na_2HPO_4	–	–	–	–	–	104.1	–	–
1.06466	Sodium hydroxide monohydrate	$NaOH \cdot H_2O$	–	109.2	126.0	178.0	–	–	52.2	1.55
1.06498	Sodium hydroxide	NaOH	–	–	–	–	313.7	341.0	–	–
1.06525	Sodium iodate	$NaIO_3$	2.5	9.1	–	23.0	27.0	32.8	–	–
1.06523	Sodium iodide	NaI	–	–	–	–	295.0	303.0	–	–
1.06537	Sodium nitrate	$NaNO_3$	70.7	88.3	104.9	124.7	148.0	176.0	46.8	1.38
1.06549	Sodium nitrite	$NaNO_2$	73.0	84.5	95.7	112.3	135.5	163.0	45.8	1.33
1.06564	Sodium perchlorate monohydrate	$NaClO_4 \cdot H_2O$	167.0	181.0	243.0	–	–	–	64.4	1.757
1.06578	tri-Sodium phosphate dodecahydrate	$Na_3PO_4 \cdot 12H_2O$	1.5	12.1	31.0	55.0	81.0	108.0	10.8	1.106
1.06648	Sodium sulfate decahydrate	$Na_2SO_4 \cdot 10H_2O$	4.56	19.2	–	–	–	–	16.1	1.150
1.06649	Sodium sulfate	Na_2SO_4	–	–	48.1	45.3	43.1	42.3	–	–
1.06638	Sodium sulfide nonahydrate	$Na_2S \cdot 9H_2O$	12.4	18.8	29.0	–	–	–	15.8	1.18
1.06657	Sodium sulfite	Na_2SO_3	–	–	37.0	33.2	29.0	26.6	–	–
1.06310	di-Sodium tetraborate	$Na_2B_4O_7$	1.2	2.7	6.0	20.3	31.5	52.5	–	–
1.06516	Sodium thiosulfate pentahydrate	$Na_2S_2O_3 \cdot 5H_2O$	52.5	70.1	102.6	–	–	–	41.2	1.39
1.01512	Silver nitrate	$AgNO_3$	115.0	219.2	334.8	471.0	652.0	1024.0	68.6	2.18
1.01509	Silver sulfate	Ag_2SO_4	0.57	0.79	0.98	1.15	1.3	1.5	0.75	–

SOLUBILITY OF INORGANIC COMPOUNDS IN WATER IN RELATION TO TEMPERATURE

Cat. No.	Name	Formula	Solubility in g/100 g H_2O at °C						Content of the total solution at 20 °C. in %	Density of the total solution at 20 °C. in %
			0	20	40	60	80	100		
1.07865	Strontiumchlorid-Hexahydrat	$SrCl_2 \cdot 6H_2O$	44.1	53.9	66.6	85.2	–	–	35.0	1.39
1.07876	Strontiumhydroxid-Octahydrat	$Sr(OH)_2 \cdot 8H_2O$	0.35	0.7	1.5	3.1	7.0	24.2	0.69	–
1.07872	Strontiumnitrat	$Sr(NO_3)_2$	–	–	91.2	94.2	97.2	101.2	–	–
8.18150	Tin(II) chloride	$SnCl_2$	83.9	269.8 (15°C)	–	–	–	–	72.96 (15°C)	2.07
1.08144	Thallium(I) nitrate	$TlNO_3$	3.81	9.5	20.9	46.2	111.0	413.0	8.7	–
8.18631	Zinc bromide	$ZnBr_2$	390.0	440.0	–	620.0	640.0	670.0	–	–
1.08816	Zinc chloride	$ZnCl_2$	–	–	453.0	488.0	541.0	–	–	–
1.08836	Zinc nitrate hexahydrate	$Zn(NO_3)_2 \cdot 6H_2O$	92.7	118.3	–	–	–	–	54.2	1.67
1.08833	Zinc nitrate tetrahydrate	$Zn(NO_3)_2 \cdot 4H_2O$	–	–	211.5	–	–	–	–	–
1.08883	Zinc sulfate heptahydrate	$ZnSO_4 \cdot 7H_2O$	41.6	53.8	–	–	–	–	35.0	1.47
1.08882	Zinc sulfate monohydrate	$ZnSO_4 \cdot H_2O$	–	–	–	76.5	66.7	60.5	–	–



SOLUBILITY PRODUCTS OF SLIGHTLY SOLUBLE INORGANIC COMPOUNDS

Substance	Formula	Solubility product at given temperature, in [mol/l]
Aluminum hydroxide	$Al(OH)_3$	4.00×10^{-13} (15°) 1.50×10^{-15} (18°) 3.70×10^{-15} (25°)
Arsenic(III) sulfide	As_2S_3	4.00×10^{-29} (18°)
Barium carbonate	$BaCO_3$	7.00×10^{-9} (16°) 8.10×10^{-9} (25°)
Barium chromate	$BaCrO_4$	1.60×10^{-10} (18°) 2.40×10^{-10} (28°)
Barium fluoride	BaF_2	1.60×10^{-6} (10°) 1.70×10^{-6} (18°)
Barium oxalate	$BaC_2O_4 \cdot 2H_2O$	1.20×10^{-7} (18°)
Barium sulfate	$BaSO_4$	8.70×10^{-11} (18°) 1.08×10^{-10} (25°) 1.98×10^{-10} (50°)
Beryllium hydroxide	$Be(OH)_2$	2.70×10^{-19} (25°)
Bismuth hydroxide	$Bi(OH)_3$	4.30×10^{-31} (18°)
Bismuth oxide chloride	BiOCl	1.60×10^{-31} (25°)
Bismuth sulfide	Bi_2S_3	1.60×10^{-72} (18°)
Cadmium carbonate	$CdCO_3$	2.50×10^{-14} (25°)
Cadmium oxalate	$CdC_2O_4 \cdot 3H_2O$	1.53×10^{-8} (18°)
Cadmium sulfide	CdS	3.60×10^{-29} (18°)
Calcium carbonate	$CaCO_3$	4.80×10^{-9} (25°)
Calcium fluoride	CaF_2	3.40×10^{-11} (18°) 3.95×10^{-11} (26°)
Calcium hydroxide	$Ca(OH)_2$	5.47×10^{-6} (18°)
Calcium oxalate	$CaC_2O_4 \cdot H_2O$	1.78×10^{-9} (18°) 2.57×10^{-9} (25°)
Calcium phosphate	$Ca_3(PO_4)_2$	1.00×10^{-25} (25°)
Calcium sulfate	$CaSO_4$	6.10×10^{-5} (10°) 2.45×10^{-5} (25°)
Calcium tartrate	$CaC_4H_4O_6 \cdot 2H_2O$	7.70×10^{-7} (25°)
Cobalt(II) carbonate	$CoCO_3$	1.00×10^{-12} (25°)
Cobalt(II) sulfide	CoS	1.90×10^{-27} (20°)
Copper(I) bromide	CuBr	4.15×10^{-8} (18–20°)
Copper(II) carbonate	$CuCO_3$	1.37×10^{-10} (25°)
Copper(I) chloride	CuCl	1.02×10^{-6} (18–20°)
Copper(II) hydroxide	$Cu(OH)_2$	5.60×10^{-20} (25°)
Copper(I) iodide	CuI	5.06×10^{-12} (18–20°)

SOLUBILITY PRODUCTS OF SLIGHTLY SOLUBLE INORGANIC COMPOUNDS

Substance	Formula	Solubility product at given temperature, in [mol/l]
Copper(I) sulfide	Cu_2S	2.00×10^{-47} (18°)
Copper(II) sulfide	CuS	8.00×10^{-45} (18°)
Copper(I) thiocyanate	CuSCN	1.60×10^{-11} (18°)
Iron(II) carbonate	$FeCO_3$	2.50×10^{-11} (20°)
Iron(II) hydroxide	$Fe(OH)_2$	1.64×10^{-14} (18°)
Iron(III) hydroxide	$Fe(OH)_3$	1.10×10^{-36} (18°)
Lanthanum hydroxide	$La(OH)_3$	$\sim 10^{-20}$ (25°)
Lead bromide	$PbBr_2$	3.90×10^{-5} (25°)
Lead carbonate	$PbCO_3$	3.30×10^{-14} (18°)
Lead chloride	$PbCl_2$	2.12×10^{-5} (25°)
Lead chromate	$PbCrO_4$	1.77×10^{-14} (25°)
Lead fluoride	PbF_2	2.70×10^{-8} (9°) 3.20×10^{-8} (18°)
Lead iodate	$Pb(IO_3)_2$	5.30×10^{-14} (9.2°) 1.20×10^{-13} (18°) 2.60×10^{-13} (25.8°)
Lead iodide	PbI_2	7.50×10^{-9} (15°) 1.40×10^{-9} (25°)
Lead oxalate	PbC_2O_4	2.74×10^{-11} (18°)
Lead sulfate	$PbSO_4$	1.06×10^{-8} (18°)
Lead sulfide	PbS	3.40×10^{-28} (18°)
Lithium carbonate	Li_2CO_3	1.70×10^{-3} (25°)
Magnesium ammonium phosphate	$MgNH_4PO_4$	2.50×10^{-13} (25°)
Magnesium carbonate	$MgCO_3$	2.60×10^{-5} (12°)
Magnesium fluoride	MgF_2	7.10×10^{-9} (18°)
Magnesium hydroxide	$Mg(OH)_2$	1.20×10^{-11} (18°)
Manganese carbonate	$MnCO_3$	8.80×10^{-10} (18°)
Manganese sulfide	MnS	7.00×10^{-16} (18°)
Mercury(I) bromide	Hg_2Br_2	1.30×10^{-21} (25°)
Mercury(I) chloride	Hg_2Cl_2	2.00×10^{-18} (25°)
Mercury(I) chromate	Hg_2CrO_4	2.00×10^{-9} (25°)
Mercury(I) cyanide	$Hg_2(CN)_2$	5.00×10^{-40} (25°)
Mercury(I) iodide	Hg_2I_2	1.20×10^{-28} (25°)
Mercury(II) iodide	HgI_2	3.20×10^{-29} (25°)
Mercury(I) oxide	Hg_2O	1.60×10^{-23} (25°)
Mercury(II) oxide	HgO	1.70×10^{-26} (25°)

SOLUBILITY PRODUCTS OF SLIGHTLY SOLUBLE INORGANIC COMPOUNDS

Substance	Formula	Solubility product at given temperature, in [mol/l]
Mercury(I) sulfide	Hg_2S	1.00×10^{-47} (18°)
Mercury(II) sulfide	HgS	3.00×10^{-54} (18°)
Nickel(II) carbonate	$NiCO_3$	1.35×10^{-7} (25°)
Nickel(II) hydroxide	$Ni(OH)_2$	1.60×10^{-14} (25°)
Nickel(II) sulfide	NiS	1.00×10^{-26} (20°)
Potassium hexachloroplatinate (IV)	K_2PtCl_6	1.10×10^{-5} (18°)
Potassium hydrogen tartrate	$KHC_4H_4O_6$	3.80×10^{-4} (18°)
Potassium perchlorate	$KClO_4$	1.07×10^{-2} (25°)
Silver arsenate	Ag_3AsO_4	1.00×10^{-19} (25°)
Silver bromide	AgBr	4.10×10^{-13} (18°) 7.70×10^{-13} (25°)
Silver chloride	AgCl	0.21×10^{-10} (4.7°) 0.37×10^{-10} (9.7°) 1.56×10^{-10} (25°) 13.2×10^{-10} (50°) 215×10^{-10} (100°)
Silver chromate	Ag_2CrO_4	1.20×10^{-12} (14.8°) 9.00×10^{-12} (25°)
Silver iodide	AgI	0.32×10^{-16} (13°) 1.50×10^{-16} (25°)
Silver sulfide	Ag_2S	1.60×10^{-49} (18°)
Silver thiocyanate	AgSCN	0.49×10^{-12} (18°) 1.16×10^{-12} (25°)
Strontium carbonate	$SrCO_3$	1.60×10^{-9} (25°)
Strontium fluoride	SrF_2	2.80×10^{-9} (18°)
Strontium oxalate	SrC_2O_4	5.60×10^{-8} (18°)
Strontium sulfate	$SrSO_4$	2.80×10^{-7} (2.9°) 3.80×10^{-7} (17.4°)
Thallium(I) bromide	TlBr	3.90×10^{-6} (25°)
Thallium(I) chloride	TlCl	1.90×10^{-4} (25°)
Thallium(I) iodide	TlI	5.80×10^{-8} (25°)
Thallium(III) hydroxide	$Tl(OH)_3$	1.40×10^{-53} (25°)
Thallium(II) sulfide	Tl_2S	9.00×10^{-23} (25°)
Thallium(I) thiocyanate	TlSCN	2.30×10^{-4} (25°)
Zinc carbonate	$ZnCO_3$	6.00×10^{-11} (25°)
Zinc hydroxide	$Zn(OH)_2$	1.00×10^{-17} (25°)
Zinc sulfide, alpha	ZnS	6.90×10^{-26} (20°)
Zinc sulfide, beta	ZnS	1.10×10^{-24} (25°)

SAMPLE PREPARATION

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SULFURIC ACID
H_2SO_4 , M = 98.08 g/mol

Density d 20°/4°	H_2SO_4 content weight%	mol/l	Density d 20°/4°	H_2SO_4 content weight%	mol/l
1.000	0.2609	0.0266	1.245	33.22	4.216
1.005	0.9855	0.101	1.250	33.82	4.310
1.010	1.731	0.1783	1.255	34.42	4.404
1.015	2.485	0.2595	1.260	35.01	4.498
1.020	3.242	0.3372	1.265	35.60	4.592
1.025	4.000	0.4180	1.270	36.19	4.686
1.030	4.746	0.4983	1.275	36.78	4.781
1.035	5.493	0.5796	1.280	37.36	4.876
1.040	6.237	0.6613	1.285	37.95	4.972
1.045	6.956	0.7411	1.290	38.53	5.068
1.050	7.704	0.8250	1.295	39.10	5.163
1.055	8.415	0.9054	1.300	39.68	5.259
1.060	9.129	0.9865	1.305	40.25	5.356
1.065	9.843	1.066	1.310	40.82	5.452
1.070	10.56	1.152	1.315	41.39	5.549
1.075	11.26	1.235	1.320	41.95	5.646
1.080	11.96	1.317	1.325	42.51	5.743
1.085	12.66	1.401	1.330	43.07	5.840
1.090	13.36	1.484	1.335	43.62	5.938
1.095	14.04	1.567	1.340	44.17	6.035
1.100	14.73	1.652	1.345	44.72	6.132
1.105	15.41	1.735	1.350	45.26	6.229
1.110	16.08	1.820	1.355	45.80	6.327
1.115	16.76	1.905	1.360	46.33	6.424
1.120	17.43	1.990	1.365	46.86	6.522
1.125	18.09	2.075	1.370	47.39	6.620
1.130	18.76	2.161	1.375	47.92	6.718
1.135	19.42	2.247	1.380	48.45	6.817
1.140	20.08	2.334	1.385	48.97	6.915
1.145	20.73	2.420	1.390	49.48	7.012
1.150	21.38	2.507	1.395	49.99	7.110
1.155	22.03	2.594	1.400	50.50	7.208
1.160	22.67	2.681	1.405	51.01	7.307
1.165	23.31	2.768	1.410	51.52	7.406
1.170	23.95	2.857	1.415	52.02	7.505
1.175	24.58	2.945	1.420	52.51	7.603
1.180	25.21	3.033	1.425	53.01	7.702
1.185	25.84	3.122	1.430	53.50	7.801
1.190	26.47	3.211	1.435	54.00	7.901
1.195	27.10	3.302	1.440	54.49	8.000
1.200	27.72	3.302	1.445	54.97	8.099
1.205	28.33	3.481	1.450	55.45	8.198
1.210	28.95	3.572	1.455	55.93	8.297
1.215	29.57	3.663	1.460	56.41	8.397
1.220	30.18	3.754	1.465	56.89	8.497
1.225	30.79	3.846	1.470	57.36	8.598
1.230	31.40	3.938	1.475	57.84	8.699
1.235	32.01	4.031	1.480	58.31	8.799
1.240	32.61	4.123	1.485	58.78	8.899

SULFURIC ACID
H_2SO_4 , M = 98.08 g/mol

Density d 20°/4°	H_2SO_4 content weight%	mol/l	Density d 20°/4°	H_2SO_4 content weight%	mol/l
1.490	59.24	9.000	1.735	80.70	14.28
1.495	59.70	9.100	1.740	81.16	14.40
1.500	60.17	9.202	1.745	81.62	14.52
1.505	60.62	9.303	1.750	82.09	14.65
1.510	61.08	9.404	1.755	82.57	14.78
1.515	61.54	9.506	1.760	83.06	14.90
1.520	62.00	9.608	1.765	83.57	15.04
1.525	62.45	9.711	1.770	84.08	15.17
1.530	62.91	9.8136	1.775	84.61	15.31
1.535	63.36	9.916	1.780	85.16	15.46
1.540	63.81	10.02	1.785	85.74	15.61
1.545	64.26	10.12	1.790	86.35	15.76
1.550	64.71	10.23	1.795	86.99	15.92
1.555	65.15	10.33	1.800	87.69	16.09
1.560	65.59	10.43	1.805	88.43	16.27
1.565	66.03	10.54	1.810	89.23	16.47
1.570	66.47	10.64	1.815	90.12	16.68
1.575	66.91	10.74	1.820	91.11	16.91
1.580	67.35	10.85	1.821	91.33	16.96
1.585	67.79	10.96	1.822	91.56	17.01
1.590	68.23	11.06	1.823	91.78	17.06
1.595	68.66	11.16	1.824	92.00	17.11
1.600	69.09	11.27	1.825	92.25	17.17
1.605	69.53	11.38	1.826	92.51	17.22
1.610	69.96	11.48	1.827	92.77	17.28
1.615	70.39	11.59	1.828	93.03	17.34
1.620	70.82	11.70	1.829	93.33	17.40
1.625	71.25	11.80	1.830	93.64	17.47
1.630	71.67	11.91	1.831	93.94	17.54
1.635	72.09	12.02	1.832	94.32	17.62
1.640	72.52	12.13	1.833	94.72	17.70
1.645	72.95	12.24			
1.650	73.37	12.43			
1.655	73.80	12.45			
1.660	74.22	12.56			
1.665	74.64	12.67			
1.670	75.07	12.78			
1.675	75.49	12.89			
1.680	75.92	13.00			
1.685	76.34	13.12			
1.690	76.77	13.23			
1.695	77.20	13.34			
1.700	77.63	13.46			
1.705	78.06	13.57			
1.710	78.49	13.69			
1.715	78.93	13.80			
1.720	79.37	13.92			
1.725	79.81	14.04			
1.730	80.25	14.16			



PHOSPHORIC ACID
H_3PO_4, M = 97.99/mol

Density d 20°/4°	H_3PO_4 content weight%	mol/l
1.0038	1	0.102
1.0092	2	0.206
1.0146	3	0.312
1.0200	4	0.416
1.0255	5	0.523
1.0309	6	0.631
1.0365	7	0.740
1.0420	8	0.851
1.0476	9	0.962
1.0532	10	1.074
1.0590	11	1.189
1.0647	12	1.304
1.0705	13	1.420
1.0764	14	1.538
1.0824	15	1.657
1.0884	16	1.777
1.0946	17	1.899
1.1008	18	2.021
1.1071	19	2.147
1.1134	20	2.272
1.1199	21	2.400
1.1263	22	2.529
1.1329	23	2.659
1.1395	24	2.791
1.1462	25	2.924
1.1529	26	3.059
1.1597	27	3.195
1.1665	28	3.333
1.1735	29	3.473
1.1805	30	3.614
1.216	35	4.333
1.254	40	5.118
1.293	45	5.938
1.335	50	6.811
1.379	55	7.740
1.426	60	8.731
1.476	65	9.784
1.526	70	10.90
1.579	75	12.08
1.633	80	13.33
1.689	85	14.65
1.746	90	16.03
1.770	92	16.61
1.794	94	17.20
1.819	96	17.82
1.844	98	18.44
1.870	100	19.08



HYDROCHLORIC ACID
HCl, M = 36.47 g/mol

Density d 20°/4°	HCl content weight%	mol/l
1.000	0.3600	0.09872
1.005	1.360	0.3748
1.010	2.364	0.6547
1.015	3.374	0.9391
1.020	4.388	1.227
1.025	5.408	1.520
1.030	6.433	1.817
1.035	7.464	2.118
1.040	8.490	2.421
1.045	9.510	2.725
1.050	10.52	3.029
1.055	11.52	3.333
1.060	12.51	3.638
1.065	13.50	3.944
1.070	14.49_5	4.253
1.075	15.48_5	4.565
1.080	16.47	4.878
1.085	17.45	5.192
1.090	18.43	5.509_5
1.095	19.41	5.829
1.100	20.39	6.150
1.105	21.36	6.472
1.110	22.33	6.796
1.115	23.29	7.122
1.120	24.25	7.449
1.125	25.22	7.782
1.130	26.20	8.118
1.135	27.18	8.459
1.140	28.18	8.809
1.145	29.17	9.159
1.150	30.14	9.505
1.155	31.14	9.863
1.160	32.14	10.225
1.165	33.16	10.595
1.170	34.18	10.97
1.175	35.20	11.34
1.180	36.23	11.73
1.185	37.27	12.11
1.190	38.32	12.50
1.195	39.37	12.90
1.198	40.00	13.14

NITRIC ACID
HNO_3, M = 63.02 g/mol

Density d 20°/4°	HNO_3 content weight%	mol/l	Density d 20°/4°	HNO_3 content weight%	mol/l
1.000	0.3333	0.05231	1.260	42.14	8.426
1.005	1.255	0.2001	1.265	42.92	8.616
1.010	2.164	0.3468	1.270	43.70	8.808
1.015	3.073	0.4950	1.275	44.48	9.001
1.020	3.982	0.6445	1.280	45.27	9.195
1.025	4.883	0.7943	1.285	46.06	9.394
1.030	5.784	0.9454	1.290	46.85	9.590
1.035	6.661	1.094	1.295	47.63	9.789
1.040	7.530	1.243	1.300	48.42	9.990
1.045	8.398	1.393	1.305	49.21	10.19
1.050	9.259	1.543	1.310	50.00	10.39
1.055	10.12	1.694	1.315	50.85	10.61
1.060	10.97	1.845	1.320	51.71	10.83
1.065	11.81	1.997	1.325	52.56	11.05
1.070	12.65	2.148	1.330	53.41	11.27
1.075	13.48	2.301	1.335	54.27	11.49
1.080	14.31	2.453	1.340	55.13	11.72
1.085	15.13	2.605	1.345	56.04	11.96
1.090	15.95	2.759	1.350	56.95	12.20
1.095	16.76	2.913	1.355	57.87	12.44
1.100	17.58	3.068	1.360	58.78	12.68
1.105	18.39	3.224	1.365	59.69	12.93
1.110	19.19	3.381	1.370	60.67	13.19
1.115	20.00	3.539	1.375	61.69	13.46
1.120	20.79	3.696	1.380	62.70	13.73
1.125	21.59	3.854	1.385	63.72	14.01
1.130	22.38	4.012	1.390	64.74	14.29
1.135	23.16	4.171	1.395	65.84	14.57
1.140	23.94	4.330	1.400	66.97	14.88
1.145	24.71	4.489	1.405	68.10	15.18
1.150	25.48	4.649	1.410	69.23	15.49
1.155	26.24	4.810	1.415	70.39	15.81
1.160	27.00	4.970	1.420	71.63	16.14
1.165	27.76	5.132	1.425	72.86	16.47
1.170	28.51	5.293	1.430	74.09	16.81
1.175	29.25	5.455	1.435	75.35	17.16
1.180	30.00	5.618	1.440	76.71	17.53
1.185	30.74	5.780	1.445	78.07	17.90
1.190	31.47	5.943	1.450	79.43	18.28
1.195	32.21	6.107	1.455	80.88	18.68
1.200	32.94	6.273	1.460	82.39	19.09
1.205	33.68	6.440	1.465	83.91	19.51
1.210	34.41	6.607	1.470	85.50	19.95
1.215	35.16	6.778	1.475	87.29	20.43
1.220	35.93	6.956	1.480	89.07	20.92
1.225	36.70	7.135	1.485	91.13	21.48
1.230	37.48	7.315	1.490	93.49	22.11
1.235	38.25	7.497	1.495	95.46	22.65
1.240	39.02	7.679	1.500	96.73	23.02
1.245	39.80	7.863	1.501	96.98	23.10
1.250	40.58	8.049	1.502	97.23	23.18
1.255	41.36	8.237	1.503	97.49	23.25

NITRIC ACID
HNO_3, M = 63.02 g/mol

Density d 20°/4°	HNO_3 content weight%	mol/l
1.504	97.74	23.33
1.505	97.99	23.40
1.506	98.25	23.48
1.507	98.50	23.56
1.508	98.76	23.63
1.509	99.01	23.71
1.510	99.26	23.79
1.511	99.52	23.86
1.512	99.77	23.94
1.513	100.0	24.01

SODIUM HYDROXIDE SOLUTION
NaOH, M = 40.01 g/mol

Density d 20°/4°	NaOH content weight%	mol/l	Density d 20°/4°	NaOH content weight%	mol/l
1.000	0.159	0.0398	1.105	9.64	2.664
1.005	0.602	0.151	1.110	10.10[5]	2.802
1.010	1.0455	0.264	1.115	10.55	2.942
1.015	1.49	0.378	1.120	11.01[5]	3.082
1.020	1.94	0.494	1.125	11.46	3.224
1.025	2.39	0.611	1.130	11.92	3.367
1.030	2.84	0.731	1.135	12.37	3.510
1.035	3.29	0.851	1.140	12.83	3.655
1.040	3.745	0.971	1.145	13.28	3.801
1.045	4.20	1.097	1.150	13.73	3.947
1.050	4.655	1.222	1.155	14.18	4.095
1.055	5.11	1.347	1.160	14.64	4.244
1.060	5.56	1.474	1.165	15.09	4.395
1.065	6.02	1.602	1.170	15.54	4.545
1.070	6.47	1.731	1.175	15.99	4.697
1.075	6.93	1.862	1.180	16.44	4.850
1.080	7.38	1.992	1.185	16.89	5.004
1.085	7.83	2.123	1.190	17.34	5.160
1.090	8.28	2.257	1.195	17.80[5]	5.317
1.095	8.74	2.391	1.200	18.25	5.476
1.100	9.19	2.527	1.205	18.71[5]	5.636

SODIUM HYDROXIDE SOLUTION
NaOH, M = 40.01 g/mol

Density d 20°/4°	NaOH content weight%	mol/l	Density d 20°/4°	NaOH content weight%	mol/l
1.210	19.16	5.796	1.370	34.03	11.65
1.215	19.62	5.958	1.375	34.52	11.86
1.220	20.07	6.122	1.380	35.01	12.08
1.225	20.53	6.286	1.385	35.505	12.29
1.230	20.98	6.451	1.390	36.00	12.51
1.235	21.44	6.619	1.395	36.495	12.73
1.240	21.90	6.788	1.400	36.99	12.95
1.245	22.36	6.958	1.405	37.49	13.17
1.250	22.82	7.129	1.410	37.99	13.39
1.255	23.275	7.302	1.415	38.49	13.61
1.260	23.73	7.475	1.420	38.99	13.84
1.265	24.19	7.650	1.425	39.495	14.07
1.270	24.645	7.824	1.430	40.00	14.30
1.275	25.10	8.000	1.435	40.515	14.53
1.280	25.56	8.178	1.440	41.03	14.77
1.285	26.02	8.357	1.445	41.55	15.01
1.290	26.48	8.539	1.450	42.07	15.25
1.295	26.94	8.722	1.455	42.59	15.49
1.300	27.41	8.906	1.460	43.12	15.74
1.305	27.87	9.092	1.465	43.64	15.98
1.310	28.33	9.278	1.470	44.17	16.23
1.315	28.80	9.466	1.475	44.695	16.48
1.320	29.26	9.656	1.480	45.22	16.73
1.325	29.73	9.875	1.485	45.75	16.98
1.330	30.20	10.04	1.490	46.27	17.23
1.335	30.67	10.23	1.495	46.80	17.49
1.340	31.14	10.43	1.500	47.33	17.75
1.345	31.62	10.63	1.505	47.85	18.00
1.350	32.10	10.83	1.510	48.38	18.26
1.355	32.58	11.03	1.515	48.905	18.52
1.360	33.06	11.24	1.520	49.44	18.78
1.365	33.54	11.45	1.525	49.97	19.05
			1.530	50.50	19.31

POTASSIUM HYDROXIDE SOLUTION
KOH, M = 56.11 g/mol

Density d 20°/4°	KOH content weight%	mol/l	Density d 20°/4°	KOH content weight%	mol/l
1.000	0.197	0.0351	1.160	17.29	3.58
1.005	0.743	0.133	1.165	17.81	3.70
1.010	1.295	0.233	1.170	18.32	3.82
1.015	1.84	0.333	1.175	18.84	3.945
1.020	2.38	0.4355	1.180	19.35	4.07
1.025	2.93	0.536	1.185	19.86	4.195
1.030	3.48	0.6395	1.190	20.37	4.32
1.035	4.03	0.774	1.195	20.88	4.45
1.040	4.58	0.848	1.200	21.38	4.57
1.045	5.12	0.954	1.205	21.88	4.70
1.050	5.66	1.06	1.210	22.38	4.83
1.055	6.20	1.17	1.215	22.88	4.955
1.060	6.74	1.27	1.220	23.38	5.08
1.065	7.28	1.38	1.225	23.87	5.21
1.070	7.82	1.49	1.230	24.37	5.34
1.075	8.36	1.60	1.235	24.86	5.47
1.080	8.89	1.71	1.240	25.36	5.60
1.085	9.43	1.82	1.245	25.85	5.74
1.090	9.96	1.94	1.250	26.34	5.87
1.095	10.49	2.05	1.255	26.83	6.00
1.100	11.03	2.16	1.260	27.32	6.135
1.105	11.56	2.28	1.265	27.80	6.27
1.110	12.08	2.39	1.270	28.29	6.40
1.115	12.61	2.51	1.275	28.77	6.54
1.120	13.14	2.62	1.280	29.25	6.67
1.125	13.66	2.74	1.285	29.73	6.81
1.130	14.19	2.86	1.290	30.21	6.95
1.135	14.705	2.975	1.295	30.68	7.08
1.140	15.22	3.09	1.300	31.15	7.22
1.145	15.74	3.21	1.305	31.62	7.36
1.150	16.26	3.33	1.310	32.09	7.49
1.155	16.78	3.45	1.315	32.56	7.63



POTASSIUM HYDROXIDE SOLUTION
KOH, M = 56.11 g/mol

Density d 20°/4°	KOH content weight%	mol/l	Density d 20°/4°	KOH content weight%	mol/l
1.320	33.03	7.77	1.425	42.60	10.82
1.325	33.50	7.91	1.430	43.04	10.97
1.330	33.97	8.05	1.435	43.48	11.12
1.335	34.43	8.19	1.440	43.92	11.28
1.340	34.90	8.335	1.445	44.36	11.42
1.345	35.36	8.48	1.450	44.79	11.58
1.350	35.82	8.62	1.455	45.23	11.73
1.355	36.28	8.76	1.460	45.66	11.88
1.360	36.735	8.905	1.465	46.095	12.04
1.365	37.19	9.05	1.470	46.53	12.19
1.370	37.65	9.19	1.475	46.96	12.35
1.375	38.105	9.34	1.480	47.39	12.50
1.380	38.56	9.48	1.485	47.82	12.66
1.385	39.01	9.63	1.490	48.25	12.82
1.390	39.46	9.78	1.495	48.675	12.97
1.395	39.92	9.93	1.500	49.10	13.13
1.400	40.37	10.07	1.505	49.53	13.29
1.405	40.82	10.22	1.510	49.95	13.45
1.410	41.26	10.37	1.515	50.38	13.60
1.415	41.71	10.52	1.520	50.80	13.76
1.420	42.155	10.67	1.525	51.22	13.92
			1.530	51.64	14.08

Ammonia
NH_3, M = 17.03 g/mol

Density d 20°/4°	NH_3 content weight%	mol/l	Density d 20°/4°	NH_3 content weight%	mol/l
0.998	0.0465	0.0273	0.932	17.24	9.44
0.996	0.512	0.299	0.930	17.85	9.75
0.994	0.977	0.570	0.928	18.45	10.06
0.992	1.43	0.834	0.926	19.06	10.37
0.990	1.89	1.10	0.924	19.67	10.67
0.988	2.35	1.365	0.922	20.27	10.97
0.986	2.82	1.635	0.920	20.88	11.28
0.984	3.30	1.91	0.918	21.50	11.59
0.982	3.78	2.18	0.916	22.125	11.90
0.980	4.27	2.46	0.914	22.75	12.21
0.978	4.76	2.73	0.912	23.39	12.52
0.976	5.25	3.01	0.910	24.03	12.84
0.974	5.75	3.29	0.908	24.68	13.16
0.972	6.25	3.57	0.906	25.33	13.48
0.970	6.75	3.84	0.904	26.00	13.80
0.968	7.26	4.12	0.902	26.67	14.12
0.966	7.77	4.41	0.900	27.33	14.44
0.964	8.29	4.69	0.898	28.00	14.76
0.962	8.82	4.98	0.896	28.67	15.08
0.960	9.34	5.27	0.894	29.33	15.40
0.958	9.87	5.55	0.892	30.00	15.71
0.956	10.405	5.84	0.890	30.685	16.04
0.954	10.95	6.13	0.888	31.37	16.36
0.952	11.49	6.42	0.886	32.09	16.69
0.950	12.03	6.71	0.884	32.84	17.05
0.948	12.58	7.00	0.882	33.595	17.40
0.946	13.14	7.29	0.880	34.35	17.75
0.944	13.71	7.60			
0.942	14.29	7.91			
0.940	14.88	8.21			
0.938	15.47	8.52			
0.936	16.06	8.83			
0.934	16.65	9.13			



COMMERCIALLY AVAILABLE CONCENTRATIONS OF SOME ACIDS AND ALKALIS

Name	Weight %	Density $d_4^{20°}$	Density (mol/l*)
Acetic acid	96	1.06	17
Acetic acid (glacial acetic acid)	99 – 100	1.06	18
Acetic acid, dilute	30	1.04	5
Ammonia solution	35	0.88	18
Ammonia solution	30	0.88	15.5
Ammonia solution	25	0.91	13.5
Formic acid	98 – 100	1.22	26
Hydriodic acid	57	1.7	7.5
Hydrobromic acid	40	1.38	7
Hydrochloric acid	25	1.12	8
Hydrochloric acid, concentr. (1.16)	32	1.16	10
Hydrochloric acid, concentr. (1.18)	36	1.18	12
Hydrochloric acid, fuming	37	1.19	12.5
Hydrofluoric acid	48	1.16	28
Hydrofluoric acid	40	1.13	23
Nitric acid, concentr.	65	1.40	14
Nitric acid, fuming	100	1.52	21
Perchloric acid	70	1.67	12
Perchloric acid	60	1.53	9
Phosphoric acid, concentr. (1.71)	85	1.71	15
Phosphoric acid, concentr. (1.75)	89	1.75	16
Potassium hydroxide solution	47	1.5	12.5
Potassium hydroxide solution	30	1.3	7
Sodium hydroxide solution	33	1.36	11
Sulfuric acid, concentr.	95 – 97	1.84	18
Sulfuric acid, dilute	25	1.18	3

* rounded off

Baumé degrees (°Bé) and density $°Be = 145 - \frac{145}{density}$

Example:

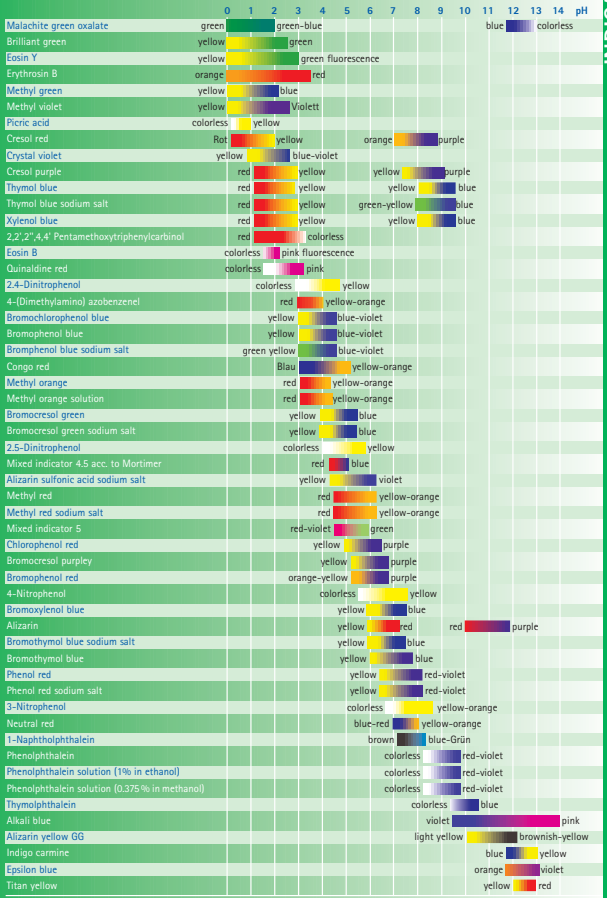
Sodium hydroxide solution 40 % with a density of 1.430 g/cm^3:

$145 - \frac{145}{1.43} = 43.60\ °Be$



INDICATORS AND BUFFERS

pH-INDICATORS



The pH ranges and color shades shown are approximations

ACID-BASE INDICATORS
(SORTED ACCORDING TO INCREASING PH TRANSITION RANGE)

Cat. No.	Indicator	Color change interval	Indicator solution (preparation)
1.01398	Malachite green oxalate (C.I. No. 42000)	0.0 – yellow 2.0 green-blue	0.1 g in 100 ml of water
1.01310	Brilliant green (C.I. No. 42040)	0.0 – yellow 2.6 green	0.1 g in 100 ml of water
1.15935	Eosin yellowish (C.I. No. 45380)	0.0 – yellow 3.0 green fluorescence	0.1 g in 100 ml of water
1.15936	Erythrosin B (C.I. No. 45430)	0.0 – orange 3.6 red	0.1 g in 100 ml of water
1.15944	Methyl green (C.I. No. 42590)	0.1 – yellow 2.3 blue	0.1 g in 100 ml of water
1.15945	Methyl violet (C.I. No. 42535)	0.1 – yellow 2.7 violet	0,1 g in 100 ml of ethanol (20 %)
1.00623	Picric acid (C.I. No. 10305)	0.2 – colorless 1.0 yellow	0,1 g in 100 ml of ethanol (20 %)
1.05225	Cresol red	0.2 – red 1.8 yellow	Dissolve 0.1 g in 100 ml of ethanol (20 %) or 0.04 g in 1.05 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.01408	Crystal violet (C.I. No. 42555)	0.8 – yellow 2.6 blue-violet	0,1 g in 100 ml of ethanol (70%)
1.05228	m-Cresol purple	1.2 – red 2.8 yellow	Dissolve 0.04 g in 100 ml of ethanol (20 %) or 0.04 g in 1.05 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.08176	Thymol blue	1.2 – red 2.8 yellow	Dissolve 0.04 g in 100 ml of ethanol (20 %) or 0.04 g in 0.86 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.08682	p-Xylenol blue	1.2 – red 2.8 yellow	Dissolve 0.1 g in 100 ml of ethanol (50%) or 0.04 g in 0.98 ml of sodium hydroxide solution 0.1 mol/l and make up to 0.1 ml with water.

ACID-BASE INDICATORS
(SORTED ACCORDING TO INCREASING PH TRANSITION RANGE)

Cat. No.	Indicator	Color change interval	Indicator solution (preparation)
1.11473	2.2', 2", 4.4'-Pentamethoxytriphenyl carbinol	1.2 – red 3.2 colorless	0.1 g in 100 ml of ethanol (96%)
1.15934	Eosin bluish (C.I. No. 45400)	1.4 – colorless 2.4 pink fluorescence	0.1 g in 100 ml of water
1.02282	Quinaldine red	1.4 – colorless 3.2 pink	0.1 g in 100 ml of ethanol (60%)
1.03464	2,4-Dinitrophenol	2.8 – colorless 4.7 yellow	0.1 g in 100 ml of ethanol (70%)
1.03055	4-(Dimethylamino) azobenzene (C.I. No. 11020)	2.9 – red 4.0 yellow-orange	0.1 – 0.5 g in 100 ml of ethanol (90%)
1.03022	Bromochlorophenol blue	3.0 – yellow 4.6 blue-violet	Dissolve 0.1 g in 100 ml of ethanol (20%) or 0.04 g in 0.69 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.08122	Bromophenol blue	3.0 – yellow 4.6 blue-violet	Dissolve 0.1 g in 100 ml of ethanol (20%) or 0.04 g in 0.6 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.01340	Congo red (C.I. No. 22120)	3.0 – blue 5.2 yellow-orange	0.2 g in 100 ml of water
1.01322	Methyl orange (C.I. No. 13025)	3.1 – blue 4.4 yellow-orange	0.04 g in 100 ml of ethanol (20%) or 0.4 g in 100 ml of water
1.01323	Methyl orange solution	3.1 – red 4.4 yellow-orange	0.04 g in 100 ml of ethanol (20%) or 0.4 g in 100 ml of water
1.01359	Mixed indicator 4.5 acc. to Mortimer	4.3 – red 5.2 blue	
1.08121	Bromocresol green	3.8 – yellow 5.4 blue	Dissolve 0.1 g in 100 ml of ethanol (20%) or 0.04 g in 0.58 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.03465	2.5-Dinitrophenol	4.0 – colorless 5.8 yellow	0.05 -0.1 g in 100 ml ethanol (70%)

ACID-BASE INDICATORS
(SORTED ACCORDING TO INCREASING PH TRANSITION RANGE)

Cat. No.	Indicator	Color change interval	Indicator solution (preparation)
1.06279	Alizarinsulfonic acid sodium salt (C.I. No. 58005)	4.3 – 6.3 yellow violet	0.1 g in 100 ml of ethanol (50%) or 0.1 g in 100 ml of water
1.06076	Methyl red (C.I. No. 13020)	4.4 – 6.2 red yellow-orange	0.1 g in 100 ml of ethanol (96%)
1.06078	Methylred sodium salt (C.I. No. 13020)	4.4 – 6.2 red yellow-orange	0.1 g in 100 ml of water
1.06130	Mixed indicator 5	4.4 – 5.8 red-violet green	
1.04795	Cacotheline	+ 0.525 18.1 yellow red-violet	saturated (irreversibly in water colorless in too strong reduction)
1.03024	Chlorophenol red	4.8 – 6.4 yellow purple	Dissolve 0.1 g in 100 ml of ethanol (20%) or 0.04 g in 0.94 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.05312	Litmus (C.I. No. 1242)	5.0 – 8.0 red blue	4 g in 100 ml of water
1.03025	Bromocresol purple	5.2 – 6.8 yellow purple	Dissolve 0.1 g in 100 ml of ethanol (20%) or 0.4 g in 0.74 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.03023	Bromophenol red	5.2 – 6.8 orange- yellow purple	Dissolve 0.1 g in 100 ml of ethanol (20%) or 0.04 g in 0.94 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.06798	4-Nitrophenol	5.4 – 7.5 colorless yellow	0.2 g in 100 ml of ethanol (96%) or 0.08 g in 100 ml of water
1.03033	Bromoxylenol blue	5.7 – 7.5 yellow blue	0.1 g in 100 ml of ethanol (96%)
1.01016	Alizarin (C.I. No. 58000)	5.8 – 7.2 yellow red	0.5 g in 100 ml Ethanol (96%)
1.03026	Bromothymol blue	6.0 – 7.6	0.1 g in 100 ml Ethanol (20%) yellow blue 0.04 g in 0.64 ml Natronlauge 0.1 mol/l lösen und mit Wasser auf 100 ml auffüllen

ACID-BASE INDICATORS
(SORTED ACCORDING TO INCREASING PH TRANSITION RANGE)

Cat. No.	Indicator	Color change interval	Indicator solution (preparation)
1.07241	Phenol red	6.4 – 8.2 yellow red-violet	Dissolve 0.1 g in 100 ml of ethanol (20%) or 0.04 g in 1.13 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.06794	3-Nitrophenol	6.6 – 8.6 colorless yellow-orange	0.3 g in 100 ml of ethanol (96%) or 0.08 g 100 ml of water
1.01369	Neutral red (C.I. No. 50040)	6.8 – 8.0 blue-red orange-yellow	0.3 g in 100 ml of ethanol (70%)
1.13857	4,5,6,7-Tetrabromo-phenolphthalein	7.0 – 8.0 colorless purple	0.1 g in 100 ml of ethanol (96%)
1.05225	Cresol red	7.0 – 8.8 orange purple	Dissolve 0.1 g in 100 ml of ethanol (50%) or 0.04 g in 1.05 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.06246	1-Naphtolphthalein	7.1 – 8.3 brownish blue-green	0.1 g in 100 ml of ethanol (96%)
1.05228	Cresol purple	7.4 – 9.0 yellow purple	Dissolve 0.04 g in 100 ml of ethanol (20%) or 0.04 g in 1.05 ml of sodium hydroxide solution 0.1 mol/l and make p to 100 ml with water.
1.08176	Thymol blue	8.0 – 9.6 yellow blue	Dissolve 0.04 g in 100 ml of ethanol (20%) or 0.04 g in 0.86 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.08682	p-Xylenol blue	8.0 – 9.6 yellow blue	Dissolve 0.1 g in 100 ml of ethanol (50%) or 0.04 g in 0.98 ml of sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water.
1.07233	Phenolphthalein	8.2 – 9.8 colorless red-violet	0.1 g in 100 ml of ethanol (96%)

ACID-BASE INDICATORS
(SORTED ACCORDING TO INCREASING PH TRANSITION RANGE)

Cat. No.	Indicator	Color change interval	Indicator solution (preparation)
1.07227	Phenolphthalein solution (1% in ethanol)	8.2 – 9.8 colorless red-violet	
1.07238	Phenolphthalein solution (0.375% in methanol)	8.2 – 9.8 colorless red-violet	
1.08175	Thymolphthalein	9.3 – 10.5 colorless blue	0.1 g in 100 ml of ethanol (50%)
1.01331	Alkali blue (C.I. No. 42765)	9.4 – 14.0 violet pink	0.1 g in 100 ml of ethanol (96%)
1.06776	Alizarin yellow GG (C.I. No. 14025)	10.0 – 12.1 light yellow brownish-yellow	0.1 g in 100 ml of water
1.01016	Alizarin (C.I. No. 58000)	10.1 – 12.1 red purple	0.5 g in 100 ml of ethanol (96%))
1.01307	Titan yellow (C.I. No. 19540)	12.0 – 13.0 yellow red	0.1 g in 100 ml of ethanol (20 %)
1.04724	Indigo carmine (C.I. No. 73015)	11.5 – 13.0 blue yellow	0.25 g in 100 ml of ethanol (50%) or 1 g in 100 ml of water
1.06810	Epsilon blue	11.6 – 13.0 orange violet	0.1 g in 100 ml of water

REDOX INDICATORS
(IN ALPHABETICAL ORDER)

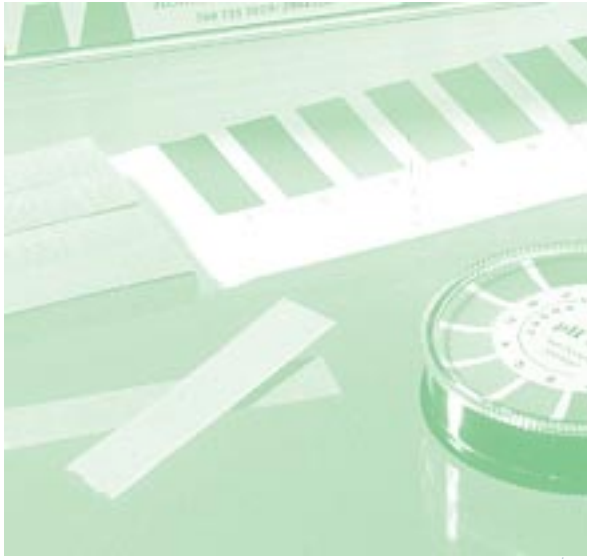
Cat. No.	Indicator	Redox potential E_0 [v] (pH=0) 20°C	Redox potential E_m [v] (pH=7) 30°C	rH	Color change oxidized form		Indicator solution (preparation)
1.01167	Amido black 10 B (C.I. No. 20470)	+ 0.57	+ 0.84		yellowish-brown	blue	0.2 g in 100 ml of water
1.03098	2.2'-Bipyridin (iron(II) complex)	+ 1.03			pale blue	red	0.695 g of $FeSO_4 \cdot 7H_2O$ + 1.171 g of 2.2'-bipyridin in 100 ml of water
1.01368	Brillant cresyl blue (C.I. No. 51010)	+ 0.58	+ 0.05		blue	colorless	0.5 g in 100 ml of water or ethanol (96%)
1.03028	2.6-Dichlorophenolindophenol sodium salt (dihydrate)	+ 0.67	+ 0.23	22	blue	colorless	0.02 g in 100 ml of water
1.03122	3.3'-Dimethylnaphthidine (4.4'-Diamino-3.3'-dimethyl-1.1'-binaphthaline)	+ 0.78			purple-red	colorless	1.0 g in 100 ml of glacial acetic acid
1.03067	N,N-Dimethyl-1.4-phenylenediammonium dichloride	+ 0.751			dark-blue	colorless	0.2 g in 100 ml of water
1.03086	Diphenylamine	+ 0.76			blue-violet	colorless	1.0 g in 100 ml of sulfuric acid (96%)
1.00255	Diphenylamine-4-sulfonic acid barium salt	+ 0.84 in Schwefelsäure 1 mol/l		28.5	red-violet	colorless	0.2 g in 100 ml of water
8.20530	Diphenylbenzidine	+ 0.76 in Schwefelsäure 1 mol/l		26 ±3.0	violet	colorless	1.0 g in 100 ml of sulfuric acid (96%)
1.09161	Ferroin indicator solution 1/40 mol/l for waste water analysis						
1.09193	Ferroin solution 1/40 mol/l						
	Ferroin (1.10-Phenanthroline iron(II) complex)	+ 1.06		40	blue	orange-red	
1.04724	Indigo carmine (Indigo disulfonate disodium salt) (C.I. No. 73015)	+ 0.29	– 0.11	10	blue	yellowish	0.05 g in 100 ml of water

REDOX INDICATORS
(IN ALPHABETICAL ORDER)

Cat. No.	Indicator	Redox potential E_0 [v] (pH=0) 20°C	E_m [v] (pH=7) 30°C	rH	Color change oxidized form		Indicator solution (preparation)
1.15943	Methylene blue (C.I. No. 52015)	+ 0.53 (30 °C)	+ 0.01	14.5	blue	colorless	0.1 – 0.5 g in 100 ml of water
1.01369	Neutral red (C.I. No. 50040)	+ 0.24	– 0.29	3	violet-red	colorless	0.05 g in 100 ml of ethanol (96%)
1.15946	Nile blue (sulfate) (C.I. No. 51180)	+ 0.41	– 0.12		blue-red	colorless	0.1 g in 100 ml of water
1.07225	1.10-Phenanthroline (monohydrate)	+ 1.14	+ 1.06		pale blue	ted	0.695 g $FeSO_4 \cdot 7H_2O$ + 1.487 g 1.10-Phenanthrolin in 100 ml of water
8.20979	N-Phenylanthranilic acid	+ 0.89			purple-red	colorless	Dissolve 0.1 g in 5 ml sodium hydroxide solution 0.1 mol/l and make up to 100 ml with water or dissolve 0.107 g in 20 ml of sodium carbonate solution (5%) and make up to 100 ml with water.
1.15498	Safranin (C.I. No. 50240)	+ 0.24	– 0.29	4	blue-violet (acidic) brown (alkaline)	colorless	0.05 g in 100 ml of water
1.13759	2.2':6'2"-Terpyridine (iron(II) complex)	+ 1.25			pale blue	rot	0.232 g $FeSO_4 \cdot 7H_2O$ + 0.389 g 2.2':6'2-terpyridine in 100 ml of water
1.15929	Thionine (C.I. No. 52000)	+ 0.56	+ 0.06	16	violet	colorless	0.05 g in 100 ml of ethanol (60%)
1.08507	Variamine blue salt B (C.I. No. 37255)	+ 0.712	+ 0.31		blue-violet (acidic) yellow (alkaline)	colorless	1.0 g in 100 ml of water or grind with sodium chloride or sodium sulfate anhydrous trituration

SUBSTANCES FOR THE PREPARATION OF BUFFER STOCK SOLUTIONS

Cat. No.	Name
1.00165	Boric acid cryst. GR for analysis
1.00244	Citric acid monohydrate GR
1.06318	5.5-Diethyl barbituric acid sodium salt buffer substance
1.04201	Glycine GR for analysis
1.04716	Imidazole buffer substance
1.04873	Potassium dihydrogen phosphate GR for analysis
1.04874	Potassium hydrogen phthalate GR
1.06268	Sodium acetate anhydrous GR for analysis
1.06267	Sodium acetate trihydrate GR for analysis
1.06392	Sodium carbonate anhydrous GR
1.06404	Sodium chloride GR for analysis
1.06329	Sodium hydrogen carbonate GR for analysis
1.06580	di-Sodium hydrogen phosphate dihydrate GR for analysis
1.08418	Titriplex®III GR for analysis
1.08379	Triethanolamine GR for analysis
1.08382	Tris(hydroxymethyl) aminomethane GR for analysis



BUFFER SOLUTIONS

Prepare stock and buffer solutions with distilled, boiled, CO_2-free water.
The volumes x (in ml) of the stock solutions required to obtain the different pH values, are listed on the next page.

Buffer solution No.	Stock solutions and their content of buffer substance A	B	Composition of buffer solution
1	Glycine 0.1 mol/l + NaCl 0.1 mol/l [Glycine: 7.507 g/l + NaCl: 5.844 g/l]	HCl 0.1 mol/l	x parts A + (100-x) parts B
2	di-Sodium citrate 0.1 mol/l [Citric acid monohydrate: 21.014 g/l + 200 ml NaOH 1 mol/l]	HCl 0.1 mol/l	x parts A + (100-x) parts B
3	Potassium hydrogen phthalate l 0.1 mol/l [$C_8H_5KO_4$: 20.42 g/l	HCl 0.1 mol/l	50 ml A + x ml B, make up to 100 ml*
4	As No. 3	NaOH 0.1 mol/l make up to 100 ml*	50 ml A + x ml B,
5	As No. 2	NaOH 0.1 mol/l (100-x) parts B	x parts A +
6	Potassium dihydrogen phosphate 1/15 mol/l [KH_2PO_4: 9.073 g/l] [$Na_2HPO_4 \cdot 2\ H_2O$: 11.87 g/l]	di-Sodium hydrogen phosphate 1/15 mol/l	x parts A + (100-x) parts B
7	5.5-Diethylbarbituric acid sodium salt 0.1 mol/l [Barbital-Na: 20.62 g/l]	HCl 0.1 mol/l	x parts A + (100-x) parts B
8	Borax solution 0.05 mol/l [H_3BO_3: 12.37 g/l + 100 ml NaOH 1 mol/l]	HCl 0.1 mol/l	x parts A + (100-x) parts B
9	As No. 1	NaOH 0.1 mol/l (100-x) parts B	x parts A +
10	Citric acid 0.1 mol/l [Citric acid monohydrate: 21.014 g/l] [$Na_2HPO_4 \cdot 2\ H_2O$: 35.60 g/l]	di-Sodium hydrogen phosphate 0.2 mol/l	x parts A + (100-x) parts B
11	Sodium acetate 0.1 mol/l [$C_2H_3O_2Na$: 8.204 g/l or $C_2H_3O_2Na \cdot 3\ H_2O$: 13.61 g/l]	Acetic acid 0.1 mol/l	x parts A + (100-x) parts B
12	Imidazole 0.2 mol/l [$C_3H_4N_2$: 13.62 g/l]	HCl 0.1 mol/l	25 ml A + x ml B, make up to 100 ml*
13	Triethanolamine 0.5 mol/l + Titriplex® III [$C_6H_{15}NO_3$: 74.60 g/l + Titriplex® III: 20 g/l]	HCl 0.05 mol/l	10 ml A + x ml B, make up to 100 ml*
14	Tris(hydroxymethyl)aminomethane 0.2 mol/l [TRIS: 24.23 g/l]	HCl 0.1 mol/l	25 ml A + x ml B, make up to 100 ml*
15	Sodium carbonate 0.1 mol/l (10.60 g/l) [Na_2CO_3: 10.60 g/l] [$NaHCO_3$: 8.401 g/l]	Sodium hydrogen carbonate 0.1 mol/l	x parts A + (100-x) parts B

* Lösung auffüllen

BUFFER SOLUTIONS



Merck KGaA · D-64271 Darmstadt Germany

BUFFER SOLUTIONS

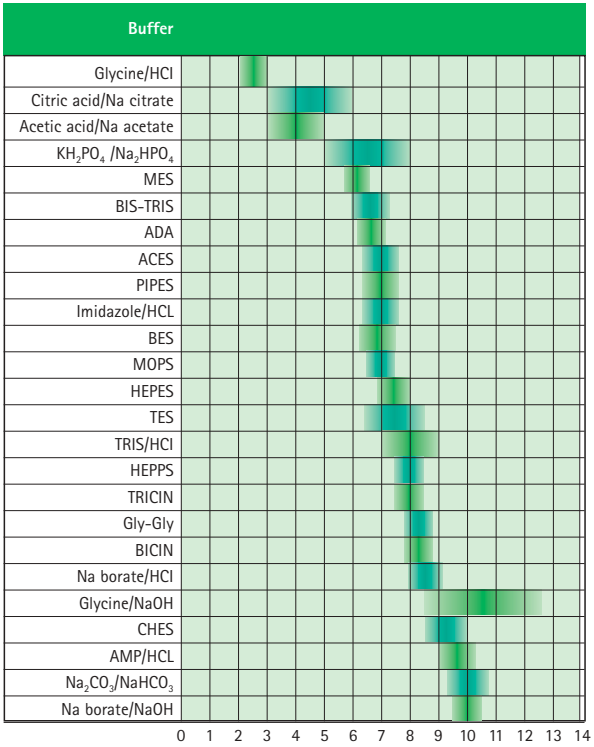
Given is the volume x (in ml) of the stock solution (made up according to the instructions on page 74) to obtain a buffer solution of the required pH.

pH	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	pH
1.0																1.0
1.2	11.1	9.0														1.2
1.4	26.4	17.9														1.4
1.6	36.2	23.6														1.6
1.8	43.9	27.6														1.8
2.0	50.7	30.2														2.0
2.2	56.5	32.2								98.8						2.2
2.4	62.3	34.1	41.0							94.5						2.4
2.6	68.4	36.0	34.3							90.0						2.6
2.8	74.7	37.9	27.8							85.1						2.8
3.0	81.0	39.9	21.6							80.3						3.0
3.2	86.2	42.1	15.9							76.0						3.2
3.4	90.3	44.8	10.9							72.0						3.4
3.6		47.8	6.7							68.4						3.6
3.8		51.2	3.3							65.1	10.9					3.8
4.0		55.1	0.0							62.0	16.6					4.0
4.2		60.0		3.0						59.1	23.9					4.2
4.4		66.4		6.7						56.4	33.5					4.4
4.6		74.9		11.1						53.7	44.9					4.6
4.8		85.6		16.5						51.2	56.6					4.8
5.0		100.0		22.6		99.2				49.0	67.8					5.0
5.2				22.8	87.1	98.4				46.9	76.8					5.2
5.4				34.4	78.0	97.3				44.7	84.0					5.4
5.6				39.1	70.3	95.5				42.2	89.3					5.6
5.8				42.4	64.5	92.8				40.0						5.8
6.0				45.0	60.3	88.9				37.4						6.0
6.2				46.7	57.2	83.0				34.5		43.4				6.2
6.4					54.8	75.4				31.4		40.4				6.4
6.6					53.2	65.3				27.9		36.5				6.6
6.8						53.4				23.5		31.4				6.8
7.0						41.3	53.3			19.0		25.4	86.2			7.0
7.2						29.6	55.0			13.8		19.6	79.6	44.7		7.2
7.4						19.7	57.6			9.8		14.6	71.3	42.0		7.4
7.6						12.8	60.8			6.8		10.2	62.0	39.3		7.6
7.8						7.4	65.2	53.0		4.6		6.6	52.0	33.7		7.8
8.0						3.7	70.6	55.4					42.0	27.9		8.0
8.2							75.6	58.0					31.9	22.9		8.2
8.4							81.2	62.1					22.5	17.3		8.4
8.6							86.2	66.9	94.7				16.0	13.0		8.6
8.8							90.1	73.6	92.0				11.7	8.8		8.8
9.0							93.2	83.5	88.4					5.3		9.0
9.2								95.6	84.0						10.0	9.2
9.4									78.9						18.4	9.4
9.6									73.2						29.3	9.6
9.8									67.2						42.0	9.8
10.0									62.5						53.4	10.0
10.2									58.8						63.7	10.2
10.4									55.7						73.1	10.4
10.6									53.6						81.2	10.6
10.8									52.2						87.9	10.8
11.0									51.2							11.0
11.2									50.4							11.2
11.4									49.5							11.4
11.6									48.7							11.6
11.8									47.6							11.8
12.0									46.0							12.0
12.2									43.2							12.2
12.4									39.1							12.4
12.6									31.8							12.6
12.8									21.4							12.8

pKa VALUES OF SELECTED BIOLOGICAL BUFFERS

Buffer	pK_a (4 °C)	pK_a (20 °C)	pK_a (25 °C)	pK_a (37 °C)	ΔpK_a/°C
ACES	7.22	6.90	6.80	6.56	-0.020
ADA	6.80	6.62	6.56	6.43	-0.011
BES	7.41	7.15	7.07	6.88	-0.016
BICIN	8.64	8.35	8.26	8.04	-0.018
BIS-TRIS	6.88	6.56	6.46	6.22	-0.020
CHES	9.73	9.55	9.50	9.36	-0.011
Citrat pK_{a2}	4.79	4.77	4.76	4.74	-0.0016
Glycin pK_{a2}	10.32	9.91	9.78	9.47	-0.026
Gly-Gly	8.85	8.40	8.26	7.92	-0.028
HEPES	7.77	7.55	7.48	7.3	-0.014
HEPPS	8.18	8.00	7.95	7.8	-0.011
Imidazole	7.37	7.05	6.95	6.71	-0.020
MES	6.33	6.15	6.10	5.97	-0.011
MOPS	7.41	7.20	7.14	6.98	-0.013
PIPES	6.94	6.80	6.76	6.66	-0.0085
Phosphate pK_{a2}	7.26	7.21	7.20	7.17	-0.0028
TAPS	8.02	8.31	8.40	8.62	+0.018
TES	7.82	7.50	7.40	7.16	-0.020
TRICIN	8.49	8.15	8.05	7.79	-0.021
TRIS	8.75	8.30	8.08	7.82	-0.028

BUFFER RANGES



PREPARATIVE AND ANALYTICAL THIN-LAYER CHROMATOGRAPHY

For every application the matching stationary phase - only MERCK offers this:

- Coarse-granular for industrial chromatography such as e.g. aluminum oxides, cellulose and, of course, all types of silica gels
- Finely classified for the demanding requirements of preparative chromatography, e.g. our LiChroprep® range
- Finely classified for all kinds of analytical HPLC such as our LiChrosorb®, LiChrospher®, Superspher® etc.
- Organic polymer resins specially designed for the requirements of biochromatography.
  From the coarsest to the most finely granulated materials the selectivities are identical. MERCK provides you with a problem-free scale-up. For every separation problem we have the most appropriate prepacked column:
  - Prepbar® stainless-steel prepacked columns for use in industrial production
  - Lobar® glass prepacked columns to solve preparative separation problems in the laboratory
  - Hibar® or LiChroCART® stainless-steel columns for analytical HPLC in all dimensions including online sample preparation
  - CGC glass cartridges for HPLC problems where chemical inertness is the key.
  - Superformance® glass cartridges and glass prepacked columns represent the inert, biocompatible and pressure-resistant system for analytical and preparative biochromatography

To satisfy all demands: for all our columns we provide a complete range of auxiliaries and the matching instrument components such as our Prepbar® system for industrial separation problems or our LiChroGraph® system for HPLC.

Should you have a chromatographical separation problem, ask MERCK first - we surely have the solution.

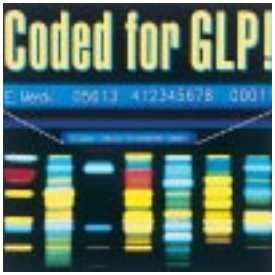
By the way, if you require special solvents for HPLC ask about our LiChrosolv® range – you will have difficulty finding better!

First of all, ask MERCK

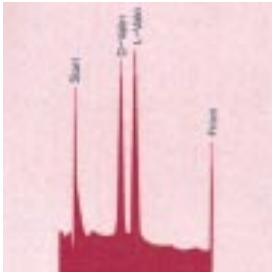
For example:
The format 2.5 cm x 7.5 cm for orientating separations (reaction process control).



For example:
Coded precoated plates for GMP/GLP-conform applications.



For example:
Chiral plates for exact separations of enantiomers.



For example:
0.5...1...2 mm layers for efficient preparative scale separations.



Detailed information on our range of ready-to-use products for thin-layer chromatography can be found in our "Chromatography Catalogue" which we shall be pleased to send you on request.



ORGANIC SOLVENTS
PROPERTIES AND DRYING

Solvent	Boiling pt. [°C]	$D^{20°}_{4°}$	$n^{20°}_{D}$	Flash pt [°C]	MAC (2) ppm	MAC (2) mg/m³	Drying agent (1)
Acetone	56	0.791	1.359	– 18	500	1200	K_2CO_3 Molecular sieve 0.3 nm
Acetic acid	118	1.049	1.372	+ 40	10	25	P_2O_5; $CuSO_4$
Acetic anhydride	136	1.082	1.390	+ 49	5	20	$CaCl_2$
Acetonitrile	82	0.782	1.344	+ 6	40	69	$CaCl_2$; P_2O_5; K_2CO_3 Molecular sieve 0.3 nm
Aniline	184	1.022	1.586	+ 76		8	KOH; BaO
Anisole	154	0.995	1.518	+ 51			$CaCl_2$; distillation; Na
Benzene	80	0.879	1.501	– 10	H.A		distillation $CaCl_2$; Na; Pb/Na Molecular sieve 0.4 nm
1-Butanol	117	0.810	1.399	+ 29	100	310	K_2CO_3; distillation
2-Butanol	100	0.808	1.398	+ 24	100	310	K_2CO_3; distillation
tert-Butanol	82	0.786	1.384	+ 11	100	310	CaO; freezing
n-Butyl acetate	127	0.882	1.394	+ 33	100	480	$MgSO_4$
Carbon disulfide	46	1.263	1.626	– 30	H 5	16	$CaCl_2$; P_2O_5
Carbon tetrachloride	77	1.594	1.460	non flammable	H 10 B	65	Distillation; $CaCl_2$; P_2O_5; Pb/Na; Molecular sieve 0.4 nm
Chlorobenzene	132	1.106	1.525	+ 29	10	47	$CaCl_2$; distillation; P_2O_5
Chloroform	62	1.486	1.448	non flammable	B.10	50	$CaCl_2$; P_2O_5; Pb/Na Molecular sieve 0.4 nm
Cyclohexane	81	0.779	1.426	– 17	200	700	Na; Na/Pb; LiAlH4 Molecular sieve 0.4 nm
Decahydronaphthalene (Dekalin)	189/ 191	0.886	1.48	< 54	–	–	$CaCl_2$; Na; Pb/Na
Dichloromethane (Methylene chloride)	40	1.325	1.424	non flammable	B.100	350	$CaCl_2$; Pb/Na Molecular sieve 0.4 nm
Diethyl carbonate	126	0.975	1.384	+ 25	–	–	K_2CO_3; Na_2SO_4
Diethylene glycoldibutyl ether	255	0.885	1.423	+ 118	–	–	$CaCl_2$; Na
Diethylene glycoldiethyl ether	188	0.906	1.412	+ 82.5	–	–	$CaCl_2$; Na
Diethylene glycol dimethyl ether	155 165	0.945	1.407	+ 70	–	–	$CaCl_2$; Na
Diethyl ether	34	0.714	1.353	– 40	400	1200	$CaCl_2$; Na; Pb/Na; $LiAlH_4$ Molecular sieve 0.4 nm
Diisopropyl ether	68	0.726	1.368	– 23	500	2100	$CaCl_2$; Na Molecular sieve 0.4 nm
Dimethyl formamide	153	0.950	1.430	+ 62	H. 10	30	Distillation Molecular sieve 0.4 nm
Dimethyl sulfoxide	189	1.101	1.478	+ 95	–	–	Distillation Molecular sieve 0.3 nm

ORGANIC SOLVENTS
PROPERTIES AND DRYING

Solvent	Boiling pt. [°C]	$D^{20°}_{4°}$	$n^{20°}_{D}$	Flash pt [°C]	MAC (2) ppm	MAC (2) mg/m³	Drying agent (1)
1.4-Dioxane	101	1.034	1.422	+ 11.8	H.B20	73	$CaCl_2$; Na Molecular sieve 0.4 nm
Ethanol	79	0.791	1.361	+ 12	1000	1900	CaO; Mg; MgO. Molecular sieve 0.3 nm
Ethyl acetate	77	0.901	1.372	– 4	400	1500	K_2CO_3; P_2O_5; Na_2SO_4. Molecular sieve 0.4 nm
Ethylene glycol	197	1.109	1.432	+ 111	–	–	Distillation; Na_2SO_4
Ethylene glycol monoethyl ether	135	0.930	1.408	+ 41	H 5	20	Distillation
Ethylene glycol monomethyl	125	0.965	1.402	+ 52	H 5	15	Distillation
Ethyl formate	54	0.924	1.360	– 20	100	300	$MgSO_4$; Na_2SO_4
Formamide	211	1.134	1.447	155	–	–	Na_2SO_4; CaO
Glycerol	290	1.260	1.475	+ 176			Distillation
Hexafluoroacetone (sesqui-hydrate)		1.685		non flammable			
n-Hexane	69	0.659	1.375	– 23	50	180	Na; Pb/Na; $LiAlH_4$. Molecular sieve 0.4 nm
Isobutanol	108	0.803	1.396	+ 28	100	300	K_2CO_3; CaO; Mg; Ca
Isobutyl methyl ketone	117	0.801	1.396	+ 15.5	20	83	K_2CO_3
Methanol	65	0.792	1.329	+ 11	H 200	270	Mg; CaO. Molecular sieve 0.3 nm
Methyl acetate	57	0.933	1.362	– 10	5	20	K_2CO_3; CaO
1-Methyl-2-pyrrolidone	202	1.0260	1.4684	+ 95	20	80	Distillation; Na_2SO_4; Molecular sieve 0.4 nm
Methyl ethyl ketone	80	0.806	1.379	– 4.4	200	600	K_2CO_3
Nitrobenzene	211	1.204	1.556	+ 92	H 1	5	$CaCl_2$; P_2O_5; Distillation
n-Pentane	36	0.626	1.358	– 49	1000	3000	Na; Pb/Na
1-Propanol	97	0.804	1.385	+ 15	–	–	CaO; Mg
2-Propanol	82	0.785	1.378	+ 12	200	500	CaO; Mg; Molecular sieve 0.3 nm
Pyridine	116	0.982	1.510	+ 20	5	15	KOH; BaO; Molecular sieve 0.4 nm
Tetrahydrofuran	66	0.887	1.405	– 17.5	50	150	Molecular sieve 0.4 nm
Tetrahydronaphthalene (Tetralin)	208	0.973	1.541	+ 78	–	–	$CaCl_2$; Na
Toluene	111	0.867	1.496	+ 4	50	190	Distillation; Ca; $CaCl_2$; Molecular sieve 0.4 nm
Trichloroethylene	87	1.462	1.477	non flammable	B. –	–	Distillation; Na_2SO_4; K_2CO_3
Xylene (isomeric mixture)	137/140	˜ 0.86	˜ 1.50	+ 25	100	440	Distillation; Na; $CaCl_2$; Molecular sieve 0.4 nm

ORGANIC SOLVENTS
PROPERTIES AND DRYING

(1) For details of drying methods please refer to the brochure "Drying in the laboratory and pilot plant"
(2) MAC values

S = Danger of absorption through the skin

A = This substance is definitely known to be a carcinogenic; no MAC values can be quoted.

B = There are grounds to suppose that this substance has carcinogenic potential.

Substances for which no MAC value is given have not been classified by the German Senate Commission on hazardous materials, though this fact is not to be construed as meaning that the substances carry no risk.

ETHANOL–WATER MIXTURES

Density D 20° 20°	% by weight ethanol	% by volume ethanol	Density D 20° 20°	% by weight ethanol	% by volume ethanol
1.00000	0	0	0.91546	50	57.8
0.99813	1	1.3	0.91322	51	58.8
0.99629	2	2.5	0.91097	52	59.8
0.99451	3	3.8	0.90872	53	60.8
0.99279	4	5.0	0.90645	54	61.8
0.99113	5	6.2	0.90418	55	62.8
0.98955	6	7.5	0.90191	56	63.8
0.98802	7	8.7	0.89962	57	64.8
0.98653	8	10.0	0.89733	58	65.8
0.98505	9	11.2	0.89502	59	66.8
0.98361	10	12.4	0.89271	60	67.7
0.98221	11	13.6	0.89040	61	68.6
0.98084	12	14.8	0.88807	62	69.9
0.97948	13	16.1	0.88574	63	70.5
0.97560	14	17.3	0.88339	64	71.5
0.97687	15	18.5	0.88104	65	72.4
0.97687	16	19.7	0.87869	66	73.3
0.97431	17	20.9	0.87632	67	74.2
0.97301	18	22.1	0.87396	68	75.1
0.97169	19	23.3	0.87158	69	76.0
0.97036	20	24.5	0.86920	70	76.9
0.96901	21	25.7	0.86680	71	77.8
0.96763	22	26.9	0.86440	72	78.6
0.96624	23	28.1	0.86200	73	79.5
0.96483	24	29.2	0.85958	74	80.4
0.96339	25	30.4	0.85716	75	81.2
0.96190	26	31.6	0.85473	76	82.1
0.96037	27	32.7	0.85230	77	83.0
0.95880	28	33.9	0.84985	78	83.8
0.95717	29	35.1	0.84740	79	84.6
0.95551	30	36.2	0.84494	80	85.4
0.95381	31	37.4	0.84245	81	86.2
0.95207	32	38.5	0.83997	82	87.1
0.95028	33	39.6	0.83747	83	87.9
0.94847	34	40.7	0.83496	84	88.7
0.94662	35	41.9	0.83242	85	89.5
0.94432	36	43.0	0.82987	86	90.2
0.94281	37	44.1	0.82729	87	91.0
0.94086	38	45.2	0.82469	88	91.8
0.93886	39	46.3	0.82207	89	92.5
0.93648	40	47.4	0.81942	90	93.2
0.93479	41	48.43	0.81674	91	94.0
0.93272	42	49.51	0.81401	92	94.7
0.93062	43	50.6	0.81127	93	95.4
0.92849	44	51.6	0.80848	94	96.1
0.92636	45	52.6	0.80567	95	96.7
0.92421	46	53.7	0.80280	96	97.4
0.92204	47	54.7	0.79988	97	98.1
0.91986	48	55.8	0.79688	98	98.7
0.91766	49	56.8	0.79383	99	99.3
			0.79074	100	100.0

DRYING AGENTS

Name	Formula	Water content of air in equilibrium, in mg/l (at 25 °C)
Aluminium oxide	Al_2O_3	0.003
Calcium chloride	$CaCl_2$	< 0.00001
Calcium hydride	CaH_2	0.14
Calcium oxide	CaO	0.003
Calcium sulfate	$CaSO_4$	0.004 – 0.07
Copper sulfate	$CuSO_4$	1.4
Dessicant sachets	SiO_2	0.003
Magnesium oxide	MgO	0.008
Magnesium perchlorate	$Mg(ClO_4)_2$	0.0005 – 0.002
Magnesium sulfate	$MgSO_4$	1.0
Molecular sieves	–	0.0001 – 0.5
Phosphorus pentoxide	P_2O_5	0.00002
Potassium hydroxide	KOH	0.002
Sicacide®	H_2SO_4*	0.003 – 0.3
Sicapent®	P_2O_5*	< 0.000025
Silica gel, blue gel	$(SiO_2)_x$	0.003
Silica gel, orange gel	SiO_2	0.003
Sodium hydroxide	NaOH	0.002
Sodium sulfate	Na_2SO_4	1.0
Sulfuric acid	H_2SO_4	0.005 – 0.3

*on siliceous supporting material

VAPOUR PRESSURE OF WATER OVER H2SO4 (AT 20 °C)

% H_2SO_4	10	20	30	40	50	55	60
p [mbar]	22,9	20,5	17,6	13,0	8,2	5,9	3,7
% H_2SO_4	65	70	75	80	85	90	
p [mbar]	2,1	1,1	0,4	0,1	0,04	0,007	

LICHROSOLV®
SOLVENTS FOR CHROMATOGRAPHY

Cat. No.	Elutropic series	Polarity index acc. to Snyder (1)	Formula	Molar mass [g/mol]	Refractive index $n_D^{20°}$	Boiling point [°C]	Vapor pressure [mbar] (20°C)	Dynamic viscosity [mPa · s] (22°C)	(40°C)	Surface tension against air or vapor [mN/m] (20 °C)	MAC value 1998 mg [ml/m³] oder [ppm]	Dielectric constant DK (20 or 25 °C)	Dipole moment acc. to Debye	ε° against Al_2O_3 (1) acc. to Snyder	Flow coefficient x [mm²/s] (DC-(silica gel 60 precoated plate) 22 °C migration distance [mm] 50	75	100
1.04390	n-Heptane	–	C_7H_{16}	100.21	1.388	98.4	48	0.40	0.33	20.4	500	1.9	0	0.01	9.2	10.6	11.4
1.04391	n-Hexane	0.0	C_6H_{14}	86.18	1.375	68.9	160	0.31	0.26	18.4	50	1.9	0	–	12.5	13.9	14.6
1.02827	Cyclohexane	0.0	C_6H_{12}	84.16	1.427	80.7	104	0.94	0.71	25.5	200	2.0	0	0.04	5.4	6.3	6.7
1.04717	Isooctane	0.4	C_8H_{18}	114.23	1.392	99.2	51	0.51	0.50	–	500	1.9	0	0.01	7.9	8.3	8.7
1.08250	1, 1.2-Trichlor-trifluorethane	–	$Cl_2FCCClF_2$	187.38	1.356	47.7	368	0.70	–	–	500	2.4	–	–	5.2	5.8	5.9
1.02223	Carbon-tetrachloride	1.7	CCl_4	153.82	1.460	76.5	120	0.97	0.74	27.0	10	2.2	0	0.18	6.1	6.7	7.0
1.08327	Toluene	2.3	$C_6H_5CH_3$	92.14	1.496	110.6	29	0.58	0.47	28.5	50	2.4	0.36	0.29	8.3	9.8	11.0
1.02444	Chloroform	4.4	$CHCl_3$	119.38	1.946	61.7	210	0.56	0.47	27.1	10	4.8	1.01	0.40	9.0	10.5	11.6
1.13713	Dichloro-ethane	3.7	$ClCH_2CH_2Cl$	98.97	1.445	83.4	87	0.80	0.65	24.2	A(3)	10.6	1.75	0.44	7.6	8.4	8.9
1.06044	Dichlor-methane	3.4	CH_2Cl_2	84.93	1.424	40.0	453	0.43	0.36	26.5	100	9.1	1.60	0.42	10.1	11.8	13.2
1.01988	1-Butanol	3.9	$CH_3(CH_2)_3OH$	74.12	1.399	117.2	6.7	2.95	1.78	24.6	100	17.8	1.66	–	–	–	–
1.00030	Acetonitrile	6.2	CH_3CN	41.05	1.344	81.6	97	0.39	–	29.3	40	37.5	3.44	0.65	12.6	14.0	15.4
1.01040	2--Propanol	4.3	$CH_3CH(OH)CH_3$	60.10	1.378	82.4	43	2.27	1.35	21.7	200	18.3	1.66	0.82	2.1	2.3	2.5
1.00868	Ethyl acetate	4.3	$CH_3COOC_2H_5$	88.10	1.372	77.1	97	0.44	0.36	23.9	400	6.0	1.78	0.58	9.2	10.9	12.1
1.00020	Acetone	5.4	CH_3COCH_3	58.08	1.359	56.2	233	0.32	0.27	23.7	500	20.7	2.70	0.56	12.7	14.7	16.2
1.11727	Ethanol	5.2	C_2H_5OH	46.07	1.361	78.5	59	1.20	0.83	22.8	1000	24.3	1.70	0.88	3.4	3.9	4.2
1.03132	1.4-Dioxane	4.8	$C_4H_8O_2$	88.11	1.422	101.0	41	1.21	0.92	33.7	20	2.2	0.40	0.56	5.2	6.0	6.5
1.08101	Tetra-hydrofuran	4.2	C_4H_8O	72.11	1.405	66.0	200	0.47	0.38	–	50	7.4	1.63	0.57	10.9	11.9	12.6
1.06007	Methanol	6.6	CH_3OH	32.04	1.329	65.0	128	0.52	0.45	22.6	200	32.6	1.70	0.95	5.6	6.5	7.1
1.15333	Water	9.0	H_2O	18.01	1.333	100.0	23	0.95	0.65	72.8	–	80.2	1.85	–	5.1	5.7	5.8

(1) acc. to L. R. Snyder, Journal of Chromatography 92, 233, (1974)

(2) Detailed solvent tables acc. to H. Halpaap can be found in:
Einführung in HPDC,
ed. R. E. Kaiser, IfC-Verlag Bad Dürkheim 1976, p. 232–233; HPTLC,
ed. A. Zlatkis, R. E. Kaiser Elsevier and IfC 1977, p. 126–127.

(3) A = This substance is definitely known to be a carcinogenic;
no MAC values can be quoted.

PHYSICAL METHODS FOR THE DETERMINATION OF ELEMENTS



FLAME PHOTOMETRY:
IMPORTANT EMISSION LINES IN THE FLAME SPECTRA OF SOME ELEMENTS

Element	Wavelength l [nm]		
Ag	328.1	338.3	
Ba	553.6	744 (B)	873 (B)
B	452 (B)	548 (B)	345 (B)
Ca	422.7	554 (B)	622 (B)
Co	346.6 (G)	353.0	387.4
Cr	360.5	427.5 (G)	425.5
Cs	455.5	852.1	894.3
Cu	324.8	327.4	520 (B)
Fe	373.7 (G)	386.0 (G)	385.6 (G)
K	404.7 (D)	766.5 (D)	344.6 (D)
Li	670.8	460.3	323.3
Mg	285.2	371 (B)	383 (B)
Mn	403.3 (G)	543.3	279.5
Na	330.3 (D)	589.3 (D)	818.3 (D)
Ni	341.5 (G)	352.5 (G)	385.8 (G)
Pb	368.4	405.8	261.4 (D)
Rb	420.2 (D)	780.0	794.8
Sr	460.7	821 (B)	407.8
Ti	377.6	535.0	276.8

(B) = Band of the oxide
(D) = Dual line, the center point between the two lines is given
(G) = Group of lines in the region of the stated wavelength

WAVELENGTH AND WAVE NUMBER

Wavelength l [nm] and wave number n [cm^{-1}]

$\bar{\nu} = \frac{1}{\lambda}$; 400 nm $\triangleq$ 25000 cm^{-1}

PHOTOMETRY:
TRANSMISSION RATE AND ABSORBANCE

$A = -\lg T$
(e.g. A = 23.6% = 0,236 ➞ T = 0.627)

CALCULATION OF THE STANDARD DEVIATION

$A = \sqrt{\Sigma F^2}$

DIRECT-CURRENT POLAROGRAPHY

HALF-WAVE POTENTIALS OF SOME IMPORTANT METALS

Metal	Half-wave potential [V]	Support electrolyte /concentration
Cu^{2+}	– 0.42	$NH_4 CH_3 COO$ 0.85 mol/l
Pb^{2+}	– 0.48	KSCN 0.0025 mol/l
Cd^{2+}	– 0.64	"
Ni^{2+}	– 1.00	"
Zn^{2+}	– 1.06	"
Co^{2+}	– 1.30	"
Fe^{2+}	– 1.41	"
Mn^{2+}	–1.55	"
Cu^{2+}	– 0.32	Saturated $CaCl_2$ solution about 10–12 mol/l
Pb^{2+}	– 0.52	"
Co^{2+}	– 0.86	"
Zn^{2+}	– 1.08	"
Mn^{2+}	– 1.40	"

CATHODE RAY POLAROGRAPHY

PEAK POTENTIALS OF SOME IMPORTANT METALS (1)

Metal	Peak potential [V]	Support electrolyte / concentration		Interference by
Zn^{2+}	– 1.03	Pyridine hydrochloride	0.1 mol/l	Co^{2+}
Cd^{2+}	– 0.63	HCl	0.2 mol/l	
Cu^{2+}	– 0.15	HCl	0.2 mol/l	Sb^{3+}
Pb^{2+}	– 0.40	HCl	0.2 mol/l	Sn^{2+}
Ni^{2+}	– 0.80	Pyridine hydrochloride	0.1 mol/l	
Bi^{3+}	– 0.08	HCl	0.5 mol/l	Cu^{2+}
Co^{2+}	– 1.05	Pyridine hydrochloride	0.1 mol/l	Zn^{2+}
Sb^{3+}	– 0.13	HCl	0.5 mol/l	Cu^{2+}
Sn^{2+}	– 0.50	HCl	5 mol/l	Pb^{2+}, Tl^{+}
Cr^{6+}	– 0.75	LiOH	0.5 mol/l	
Cr^{3+}	– 1.10	LiCl	0.5 mol/l	Zn^{2+}

(1) measured against a silver/silver chloride reference electrode





MASS AND WEIGHT

ENERGY DIMENSIONS – CONVERSION FACTORS

Given dimension	Required dimension with conversion factor (2)					
Unit	J	kWh	MeV	mkp	$kcal_{15°}$	erg
1 J (1)	1	$2.77778 \cdot 10^{-7}$	$6.242 \cdot 10^{12}$	0.1019716	$2.38920 \cdot 10^{-4}$	10^{7}
1 kWh (1)	3600000	1	$2.247 \cdot 10^{19}$	367097.8	860.11	$3.6 \cdot 10^{13}$
1 MeV (1)	$1.602 \cdot 10^{-13}$	$4.45 \cdot 10^{-20}$	1	$1.634 \cdot 10^{-14}$	$3.827 \cdot 10^{-17}$	$1.602 \cdot 10^{-6}$
1 mkp	9.80665	$2.72407 \cdot 10^{-6}$	$6.124 \cdot 10^{13}$	1	$2.34301 \cdot 10^{-3}$	$9.80665 \cdot 10^{7}$
$1\ kcal_{15°}$	4185.5	$1.16264 \cdot 10^{-3}$	$2.613 \cdot 10^{16}$	426.80	1	$4.1855 \cdot 10^{10}$
1 erg	10^{-7}	$2.77778 \cdot 10^{-14}$	$6.242 \cdot 10^{5}$	$0.1019716 \cdot 10^{-7}$	$2.38920 \cdot 10^{-11}$	1

(1) Legal measurement units

(2) Examples: 1 J = 2.38920·10–4 kcal 1 MeV = 1.602·10 –13J

PRESSURE DIMENSIONS – CONVERSION FACTORS

Given dimension	Required dimension with conversion factor (2)					
Unit	$N \cdot m^{-2}$ (Pa)	bar	atm	$kp \cdot m^{-2}$	Torr (mm Hg)	lbs/sq.in. (psi)
$1\ N \cdot m^{-2}$ 1 Pa (1)	1	10^{-5}	$9.8692 \cdot 10^{-6}$	$1.019710 \cdot 10^{-1}$	$7.50062 \cdot 10^{-3}$	$1.45038 \cdot 10^{-4}$
1 bar (1)	10^{5}	1	0.98692	10197.16	750.062	14.5038
1 atm	101325	1.01325	1	10332.27	759.9988	14.6960
$1\ kp \cdot m^{2}$	9.80665	$9.80665 \cdot 10^{-5}$	$9.67841 \cdot 10^{-5}$	1	$7.35559 \cdot 10^{-2}$	$1.42234 \cdot 10^{-3}$
1 Torr (1 mm Hg)	133.3224	$1.333224 \cdot 10^{-3}$	$1.31579 \cdot 10^{-3}$	13.5951	1	$1.93368 \cdot 10^{-2}$
10 lbs/sq.in. (psi)	68948	0.68948	0.68046	7030.68	517.148	10

(1) Legal measurement units

(2) Examples: 1 Pa = 7.50062·10–3Torr 10 psi = 0.68046 atm

DECIMAL UNIT MULTIPLES AND SUBDIVISIONS

Prefix		Symbol	Prefix		Symbol
10^{18}	Exa	E	10^{-1}	Deci	d
10^{15}	Peta	P	10^{-2}	Centi	c
10^{12}	Tera	T	10^{-3}	Milli	m
10^{9}	Giga	G	10^{-6}	Micro	µ
10^{6}	Mega	M	10^{-9}	Nano	n
10^{3}	Kilo	k	10^{-12}	Piko	p
10^{2}	Hecto	h	10^{-15}	Femto	f
10	Deca	da	10^{-18}	Atto	a

CONCENTRATIONS

Proportion	Potency	%	g/kg mg/g µg/mg	ppm mg/kg µg/g ng/mg	ppb µg/kg ng/g pg/mg	ppt ng/kg pg/g fg/mg
1 : 100	1×10^{-2}	1	10	10 000		
1 : 1 000	1×10^{-3}	0.1	1	1 000		
1 : 10 000	1×10^{-4}	0.01	0.1	100		
1 : 100 000	1×10^{-5}	0.001	0.01	10		
1 : 1million	1×10^{-6}	0.000 1	0.001	1	1 000	
1 : 10 million	1×10^{-7}	0.000 01	0.000 1	0.1	100	
1 : 100 Millionen	1×10^{-8}	0.000 001	0.000 01	0.01	10	
1 : 1 Milliarde	1×10^{-9}	0.000 000 1	0.000 001	0.001	1	1 000
1 : 10 Milliarden	1×10^{-10}				0.1	100
1 : 100 Milliarden	1×10^{-11}				0.01	10
1 : 1 Billion	1×10^{-12}				0.001	1

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BASIC UNITS

Dimension	Basic unit Name	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of substance	Mole	mol

DERIVED UNITS
WITH CONVERSION OF PREVIOUS UNITS

Size	SI unit Name	Symbol	Further units Name	Symbol	Relationship
LENGTH, SURFACE, VOLUME					
Length	Meter	m			
Surface	Square meter	m^2			
Volume	Cubic meter	m^3	Liter	l	$1\ l = 10^{-3}\ m^3$
MASS					
Mass	Kilogram	kg			
			Metric ton	t	$1\ t = 10^3\ kg$
			Atomic mass unit	u	$1\ u = 1{,}66053 \cdot 10^{-27}\ kg$
Density	Kilogram per cubic meter	$kg \cdot m^{-3}$			
Specific volume	Cubic meter per kilogram	$m^3 \cdot kg^{-1}$			
AMOUNT OF SUBSTANCE					
Amount of substance	Mole	mol			
Molar mass	Mass per amount of substance	$kg \cdot mol^{-1}$		$g \cdot mol^{-1}$	
Concentration of a substance	Amount of substance in given volume of solvent	$mol \cdot m^{-3}$		$mol \cdot l^{-1}$	
Molality	Amount of substance per mass of solvent	$mol \cdot kg^{-1}$		$mol \cdot g^{-1}$	

DERIVED UNITS
WITH CONVERSION OF PREVIOUS UNITS

Size	SI unit Name	Symbol	Further units Name	Symbol	Relationship
TEMPERATURE					
Temperature	Kelvin	K	Degree centigrade	°C	
TIME					
Time Time interval	second	s			
			minute	min	1 min = 60 s
			hour	h	1 h = 60 min
			day	d	1 d = 24 h
Frequency	Hertz	Hz			1 Hz = $1s^{-1}$
Velocity	Meter per second	$m \cdot s^{-1}$			
			Kilometer per hour	$km \cdot h^{-1}$	1 $km \cdot h^{-1}$ = $\frac{1}{3.6}$ $m \cdot s^{-1}$
VISCOSITY					
Dynamic viscosity	Pascal-second	Pa·s			1 Pa·s = 1 $N \cdot s \cdot m^{-2}$ = 1 $kg \cdot m^{-1} \cdot s^{-1}$
			Poise	P	1 P = 0.1 Pa·s
			Centipoise	cP	1 cP = 0.01 P = 0.001 Pa·s = mPa·s
Kinematic viscosity	Square meters per second	$m^2 \cdot s^{-1}$	Stokes	St	1 St = 1 $cm^2 \cdot s_{-1}$
			Centistoke	cSt	1 cSt = 1 $mm^2 \cdot s^{-1}$

DERIVED UNITS
WITH CONVERSION OF PREVIOUS UNITS

Size	SI unit Name	Symbol	Further units Name	Symbol	Relationship
FORCE, ENERGY, POWER					
Force	Newton	N			1 N = 1 $kg \cdot m \cdot s^{-2}$
Pressure	Newton per square meter	$N \cdot m^{-2}$			
	Pascal	Pa			1 Pa = 1 $N \cdot m^{-2}$
			Bar	bar	1 bar = 10^5 Pa
Energy, work heat quantity	Joule	J			1 J = 1 N·m = 1 W·s = 1 $kg \cdot m^2 \cdot s^{-2}$
			Kilowatt-hour	kW·h	1 kW·h = 3.6 MJ
Power	Watt	W			1 W = 1 $J \cdot s^{-1}$ = 1 $Nm \cdot s^{-1}$ = 1 VA

DERIVED UNITS

Size	SI unit Name	Symbol	Further units Name	Symbol	Relationship
ELECTRICAL MEASURES					
Electric current	Ampere	A			
Electric potential	Volt	V			
Electric conductance	Siemens	S			1 S = 1 $A \cdot V^{-1}$
Electric resistance	Ohm	V			1 V = 1 $V \cdot A^{-1}$ = 1 S^{-1}
Electric charge	Coulomb	C	Ampere-hour	A x h	1 C = 1 A·s 1 A·h = 3600 A·s
Electric capacitance	Farad	F			1 F = 1 $C \cdot V^{-1}$
LUMINOUS INTENSITY					
Luminous intensity	Candela	cd			
Luminous flux	Lumen	lm			1 lm = 1 cd·sr
Illuminance	Lux	lx			1 lx = 1 $lm \cdot m^{-2}$ = 1 $cd \cdot sr \cdot m^{-2}$

DERIVED UNITS

Size	SI unit Name	Symbol	Further units Name	Symbol	Relationship
IONIZING RADIATION					
Actitvity	Becquerel	Bq	Curie	Ci	1 Bq = 1 s^{-1} 1 Ci = 37 G Bq
ENZYMATIC ACTIVITY					
Enzymatic activity	Katal	kat	Enzyme unit	U	1 kat = 1 $mol \cdot s^{-1}$ = 60 $mol \cdot min^{-1}$ 1 U = 1 $mol \cdot s^{-1}$ = $\frac{1}{60}$ µkat = 16.67 nkat

US AND BRITISH MEASURING UNITS
CONVERSION TO METRIC UNITS

VOLUME

Liters	x	0.2642	= US gallons
US gallons	x	3.785	= Liters
Imperial gallons	x	1.201	= US gallons
Imperial gallons	x	4.546	= Liters
US gallons	x	0.8327	= Imperial gallons
Cubic meters	x	35.31	= Cubic feet
Cubic feet	x	0.0283	= Cubic meters
Cubic meters	x	264.2	= US gallons
US gallons	x	0.00379	= Cubic meters

LENGTH

Meters	x	3.281	= Feet
Feet	x	0.3048	= Meters
Meters	x	39.37	= Inches
Inches	x	0.0254	= Meters
Centimeters	x	0.3937	= Inches
Inches	x	2.540	= Centimeters
Millimeters	x	0.0394	= Inches
Inches	x	25.4	= Millimeters

WEIGHT

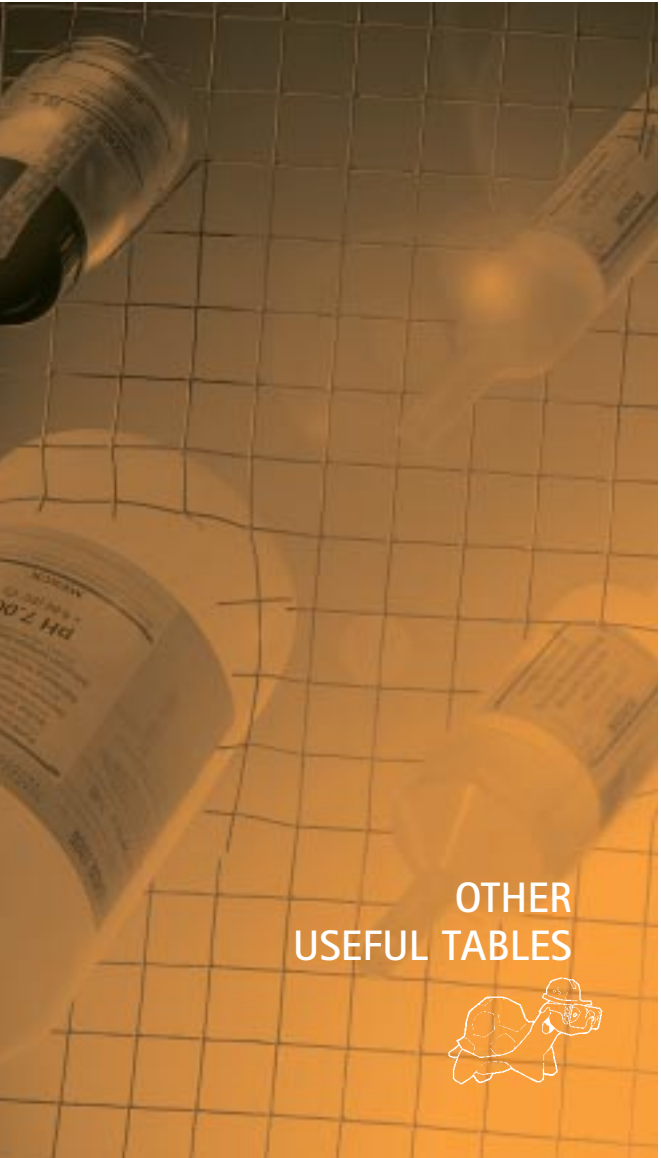
Kilograms	x	2.2046	= Pounds
Pounds	x	0.4536	= Kilograms
Tons (long)	x	1016.05	= Kilograms
Tons (long)	x	2240	= Pounds
Tonnes (metr.)	x	1000	= Kilograms
Tonnes (metr.)	x	2204.6	= Pounds
Tons (short)	x	907.185	= Kilograms
Tons (short)	x	2000	= Pounds
Grams	x	15.432653	= Grains
Grains	x	0.0647989	= Grams
Grams	x	0.0352740	= Ounces (US)
Ounces (US)	x	28.349527	= Grams
Ounces (troy)	x	31.1035	= Grams

US AND BRITISH MEASURING UNITS
CONVERSION TO METRIC UNITS

TEMPERATURE

given in	°Centigrade	required in °Réaumur	°Fahrenheit
a ° Centigrade	–	$\frac{a \cdot 8}{10}$	$\frac{a \cdot 18}{10} + 32$
b ° Réaumur	$\frac{b \cdot 10}{8}$	–	$\frac{b \cdot 18}{8} + 32$
c ° Fahrenheit	$\frac{(c - 32) \cdot 10}{18}$	$\frac{(c - 32) \cdot 8}{18}$	–

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
– 40	– 40	+ 5	41	50	122	95	203	140	284	185	365
– 35	– 31	10	50	55	131	100	212	145	293	190	374
– 30	– 22	15	59	60	140	105	221	150	302	195	383
– 25	– 13	20	68	65	149	110	230	155	311	200	392
– 20	– 4	25	77	70	158	115	239	160	320	210	410
– 15	+ 5	30	86	75	167	120	248	165	329		
– 10	14	35	95	80	176	125	257	170	338		
– 5	23	40	104	85	185	130	266	175	347		
0	32	45	113	90	194	135	275	180	356		



OTHER USEFUL TABLES

PHYSICAL CONSTANTS

Constant	Symbol	Value	
Atomic mass unit	m_U	$1.660540 \cdot 10^{-27}$	kg
Avogadro constant	N_A	$6.022137 \cdot 10^{23}$	mol^{-1}
Bohr magneton	μ_B	$9.274015 \cdot 10^{-24}$	JT^{-1}
Bohr radius	a_0	$5.291771 \cdot 10^{-11}$	m
Boltzmann constant	k_B	$1.380662 \cdot 10^{-23}$	JK^{-1}
Compton wavelength (e)	λ_{Ce}	$2.426311 \cdot 10^{-12}$	m
Compton wavelength (n)	λ_{Cn}	$1.319591 \cdot 10^{-15}$	m
Compton wavelength (p)	λ_{Cp}	$1.321410 \cdot 10^{-15}$	m
Electric field constant in vacuo	ε_0	$8.854188 \cdot 10^{-12}$	Fm^{-1}
Electron radius	τ_e	$2.817941 \cdot 10^{-15}$	m
Elementary charge	e	$1.602177 \cdot 10^{-19}$	C
Faraday constant	F	$9.648531 \cdot 10^{4}$	$Cmol^{-1}$
Fine structure constant	α	$7.297353 \cdot 10^{-3}$	
Gas constant	R	8.31451	$J\ mol^{-1}K^{-1}$
Gravitation constant	f	$6.672590 \cdot 10^{-11}$	Nm^2kg^{-2}
Intrinsic impedance	Γ	$3.767301 \cdot 10^{2}$	Ω
Light velocity in vacuo	c	$2.997924 \cdot 10^{8}$	ms^{-1}
Loschmidt constant	N_L	$2.686763 \cdot 10^{25}$	m^{-3}
Magnetic field constant in vacuo	μ_0	$1.256637 \cdot 10^{-7}$	Hm^{-1}
Molar volume of ideal gases 298 K, 101.325 kPa	v	$2.445294 \cdot 10^{-2}$	m^3mol^{-1}
Normal acceleration of fall	g	9.80665	ms^{-2}
Planck constant	h	$6.626075 \cdot 10^{-34}$	Js
Rest mass of the electron	m_e	$9.109390 \cdot 10^{-31}$	kg
Rest mass of the neutron	m_n	$1.674929 \cdot 10^{-27}$	kg
Rest mass of the proton	m_p	$1.672623 \cdot 10^{-27}$	kg
Rotational quantum	$h/(2\pi)$	$1.054588 \cdot 10^{-34}$	Js
ydberg constant	R_∞	$1.097373 \cdot 10^{7}$	m^{-1}

CREATING CONSTANT AIR HUMIDITY IN CLOSED VESSELS

Saturated aqueous solution with considerable precipitates		% relative air humidity above the solution (at 20 °C)
di-Sodium hydrogen phosphate	$Na_2HPO_4 \cdot 12\,H_2O$	95
Sodium carbonate	$Na_2CO_3 \cdot 10\,H_2O$	92
Zinc sulfate	$ZnSO_4 \cdot 7\,H_2O$	90
Potassium chloride	KCl	86
Ammonium sulfate	$(NH_4)_2SO_4$	80
Sodium chloride	NaCl	76
Sodium nitrite	$NaNO_2$	65
Ammonium nitrate	NH_4NO_3	63
Calcium nitrate	$Ca\,(NO_3)_2 \cdot 4\,H_2O$	55
Potassium carbonate	K_2CO_3	45
Zinc nitrate	$Zn\,(NO_3)_2 \cdot 6\,H_2O$	42
Calcium chloride	$CaCl_2 \cdot 6\,H_2O$	32
Lithium chloride	$LiCl \cdot H_2O$	15



GREEK ALPHABET

Letter		Name	Pronunciation
A	α	álpha	a
B	β	béta	b
Γ	γ	gámma	g
Δ	δ	délta	d
E	ε	épsilon	e (short)
Z	ζ	zéta	z
H	η	éta	e (long)
Θ	ϑ	théta	th
I	ι	ióta	i
K	κ	káppa	k
Λ	λ	lámbda	l
M	μ	mü	m
N	ν	nü	n
Ξ	ξ	xi	x
O	ο	ómicron	o (short)
Π	π	pi	p
P	ρ	rho	r
Σ	σ1, ς2	sigma	s
T	τ	tau	t
Y	υ	ýpsilon	y
Φ	φ	phi	ph
X	χ	chi	ch
Ψ	ψ	psi	ps
Ω	ω	ómega	o (long)

1 At the beginning and in the middle of a word.
2 At the end of a word.

GREEK NUMERALS / ROMAN NUMBERS

½	hemi –	
1	mono –	I
1½	sesqui –	
2	di –, bi –	II
2½	hemipenta –	
3	tri –	III
4	tetra –	IV
5	penta –	V
6	hexa –	VI
7	hepta –	VII
8	octa –	VIII
9	nona –, ennea –	IX
10	deca –	X
11	hendeca –, undeca	XI
12	dodeca –	XII
13	trideca	XIII
14	tetradeca –	XIV
15	pentadeca –	XV
16	hexadeca –	XVI
17	heptadeca –	XVII
18	octadeca –	XVIII
19	nonadeca –	XIX
20	eicosa –	XX
40	tetraconta –	XL
50	pentaconta –	L
60	hexaconta –	LX
90	nonaconta –	XC
99		IC
100	hecta –	C
200		CC
400		CD
500		D
600		DC
900		CM
990		XM
1000		M

FREEZING MIXTURES

The numbers represent weight proportions		Lowering temperature from [°C] to
4 water	+ 1 potassium chloride	+ 10 – 12
1 water	+ 1 ammonium nitrate	+ 10 – 15
1 water	+ 1 sodium nitrate + 1 ammonium chloride	+ 8 – 24
3 ice ground	+ 1 sodium chloride	0 – 21
1,2 ice ground	+ 1 magnesium chloride ($MgCl_2 \cdot 7\ H_2O$)	0 – 34
1,2 ice ground	+ 2 calcium chloride ($CaCl_2 \cdot 6\ H_2O$)	0 – 39
1,4 ice ground	+ 2 calcium chloride ($CaCl_2 \cdot 6\ H_2O$)	0 – 55
Methanol or acetone	+ dry ice	+ 15 – 77
Diethyl ether	+ dry ice	+ 15 – 100

EXTRAN® LABORATORY CLEANING AGENTS

Cat. No.	Name	Notes on use
1.07555	**Extran® MA 01** alkaline / liquid	Universal cleaning agent for heavy contamination. For hard water even up to 40° d. For cleaning tables, tiles, and floors in the laboratory. Tested for radioactive decontamination. Suitable for ultrasonic cleaning.
1.07553	**Extran® MA 02** neutral / liquid	Special cleaner for precision instruments of glass, quartz and sensitive metals. Suitable for ultrasonic cleaning.
1.07550	**Extran® MA 03** phosphate-free liquid	Universal cleaning agent for heavy contamination. With very hard water also usable without restric tions. Environmentally friendly as it contains no phosphate. Suitable for ultrasonic cleaning.
1.07551	**Extran® MA 04** disinfecting	For manual instrument disinfection.
1.07558	**Extran® AP 11** mildly alkaline/ powder	Gentle cleaning action; e.g. in the analytical laboratory. Cleaning action equivalent to that of AP 14 liquid.
1.07563	**Extran® AP 12** alkaline/powder	Powerful cleaning action. Particularly with starch and protein residues. Cleaning action equivalent to that of AP 15 liquid.
1.07565	**Extran® AP 13** alkaline with detergents/ powder	Powerful cleaning action. Particularly with fat residues.
1.07573	**Extran® AP 14** mildly alkaline/ liquid	Gentle cleaning action for machines with liquid liquid dosing; e.g. in the analytical laboratory. Environmentally friendly as it contains no phosphate. Cleaning action equivalent to that of AP 11 powder.
1.07575	**Extran® AP 15** alkaline/liquid	Powerful cleaning for machines with liquid dosing. Environmentally friendly as it contains no phosphate. Cleaning action equivalent to that of AP 12 powder.
1.07559	**Extran® AP 21** acidic with phosphoric acid liquid	First rinse in the presence of residues of carbonates, hydroxides, proteins, amines, etc. Neutralising Neutralising final rinse. Also for a gentle main wash. Prevents the formation of calcareous deposits.
1.07561	**Extran® AP 22** acidic with citric acid liquid	Gentle prerinse or final rinse with neutralizing action. Prevents the formation of calcareous deposits. Environmentally friendly as it contains no phosphate.
1.07560	**Extran® AP 31** antifoam/ liquid	Additive for foam-forming residues: proteins, fats, emulsifiers of all types.
1.07556	**Extran® AP 32** clear-rinse/ liquid	Final rinse: gives spotless surfaces even with hard water. Environmentally friendly as it contains no phosphate.
1.07570	**Extran® AP 41** enzymatic/ powder	For medical and dental practices, anaesthetic equipment. For the removal of mucus, saliva, blood etc. Temperature: 55–65 °C.

EXTRAN® LABORATORY CLEANING AGENT

Cat. No.	Name	Notes on use
1.07571	**Extran® AP 42** fat emulsion/ liquid	Machine washing: in the final rinse for restoring the lubrication of surgical instruments. Manually: 5-minute immersion in 100 ml/l
1.07584	**Extran® AP 43** bactericidal/ liquid	For disinfection after the main wash; e.g. operation shoes. Temperature: 40–60 °C/15 minutes. Environmentally friendly as it contains no phosphate.



PARTICLE SIZES

Mesh size w

DIN 4188 (D) [mm]	ASTM E11–70 (USA) [mesh]	ASTM E161–70 (USA) [µm]	BS 410 : 1969 (GB) [µm]	Tyler [mesh]
		5		
		10		
		15		
0.02				
0.022		22		
0.025				
		27		
0.028				
0.032		32		
0.036				
	400	38	38	400
0.04				
0.045	325	45	45	325
0.05				
	270	53	53	270
0.056				
0.063	230	63	63	250
0.071				
	200	75	75	200
0.08				
0.09	170	90	90	170
0.1				
	140	106	106	150
0.112				
0.125	120	125	125	115
0.14				
	100	150	150	100
0.16				
0.18	80		180	80
0.2				
	70		212	65
0.224				
0.25	60		250	60
0.28				
	50		300	48
0.315				
0.355	45		355	42
0.4				

PARTICLE SIZES

Mesh size w

DIN 4188 (D) [mm]	ASTM E11–70 (USA) [mesh]	ASTM E161–70 (USA) [µm]	BS 410 : 1969 (GB) [µm]	Tyler [mesh]
	40		425	35
0.45				
0.5	35		500	32
0.56				
	30		600	28
0.63				
0.71	25		710	24
0.8				
	20		850	20
0.9				
1	18		1000	16
1.12				
1.18	16		1180	14
1.25				
1.4	14		1400	12
1.6				
	12		1700	10
1.8				
2	10		2000	9
2.24				
	8		2360	8
2.5				
2.8	7		2800	7
3.15				
	6		3350	6
3.55				
4	5		4000	5
4.5				
	4		4750	4
5				
5.6	3½″		5600	3½

NMR: CARBON (13C) CHEMICAL SHIFTS

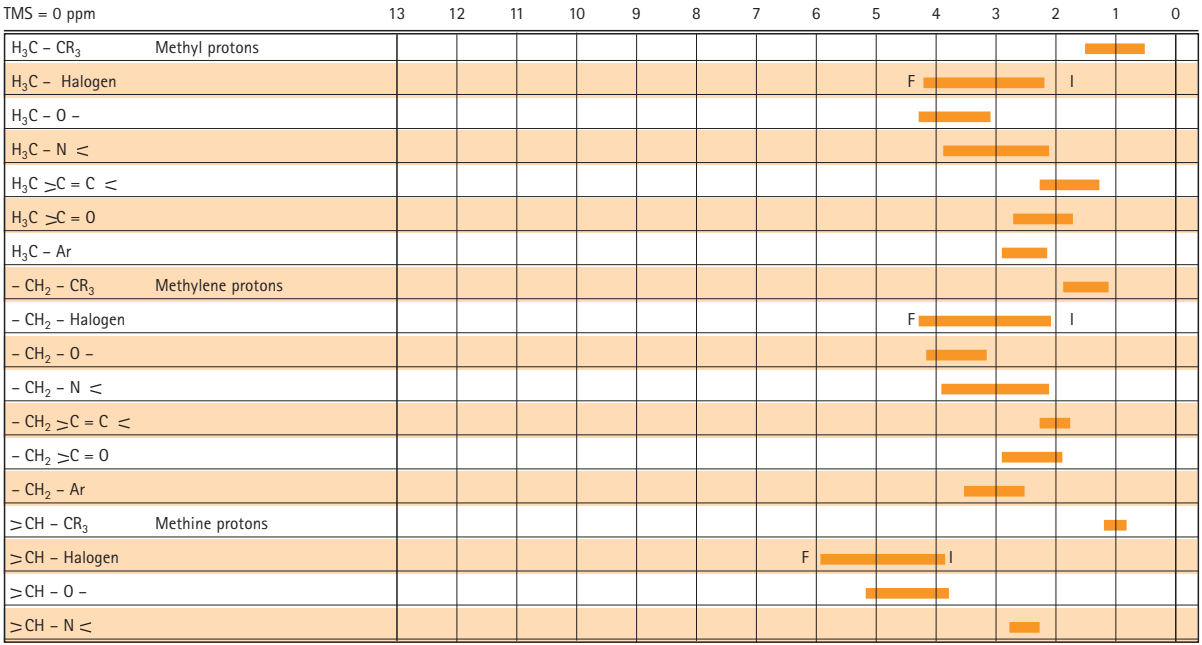
TMS = 0 ppm	220	200	180	160	140	120	100	80	60	40	20	0	−20	−40
$H_3C-C\leqslant$ C primary														
H_3C- Halogen										Cl				I
H_3C-O-														
$H_3C-N\leqslant$														
H_3C-S-														
$-CH_2-C\leqslant$ C secondary											aliphates — cyclopropanes			
$-CH_2-$ Halogen										Cl			I	
$-CH_2-O-$														
$-CH_2-N\leqslant$														
$-CH_2-S-$														
$\geqslant CH-C\leqslant$ C tertiary														
$\geqslant CH-$ Halogen									Cl		I			
$\geqslant CH-O-$														
$\geqslant CH-N\leqslant$														
$\geqslant CH-S-$														
$\geqslant C-C\leqslant$ C quaternary														
$\geqslant C-$ Halogen								Cl			I			
$\geqslant C-O-$														

NMR: CARBON (13C) CHEMICAL SHIFTS

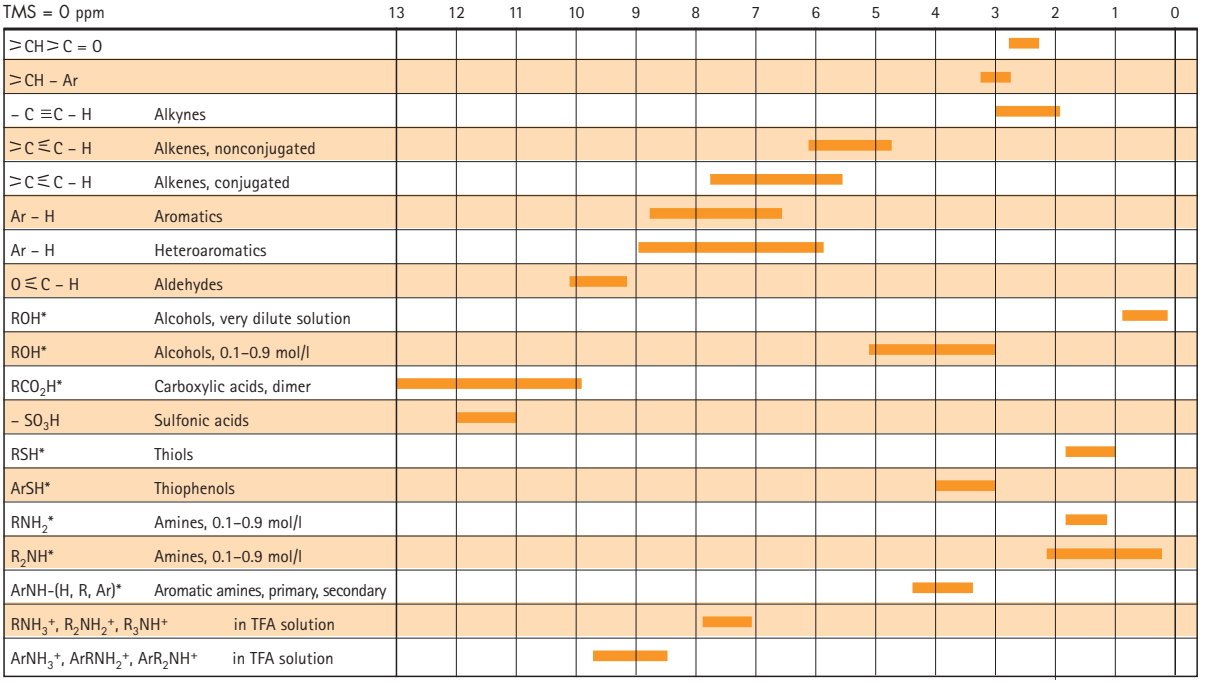
TMS = 0 ppm		220	200	180	160	140	120	100	80	60	40	20	0	−20	−40
≥C – S –									■						
≥C – C≤	Alkanes										■	■			
– C ≡C –	Alkynes							■	■						
≥ C = C≤	Alkenes					■	■								
≥ C = C≤	Aromatics					■	■								
≥ C = C≤	Heteroaromatics				■	■	■								
– O – C≡N	Cyanates				■	■									
– S – C≡ N	Thiocyanates						■	■							
– C ≡ N	Cyanides						■	■							
≥C = N –	Azomethines				■	■									
$(-CO)_2O$	Anhydrides				■										
– COOR	Esters				■										
$(-CO)_2NR$	Imides			■	■										
– CONHR	Amides			■	■	■									
– COOH	Acids			■	■										
– COCl	Acid chlorides			■	■										
– C = O	Aldehydes		■	■	■										
≥C = O	Ketones	■	■	■	■										



NMR: PROTON CHEMICAL SHIFTS

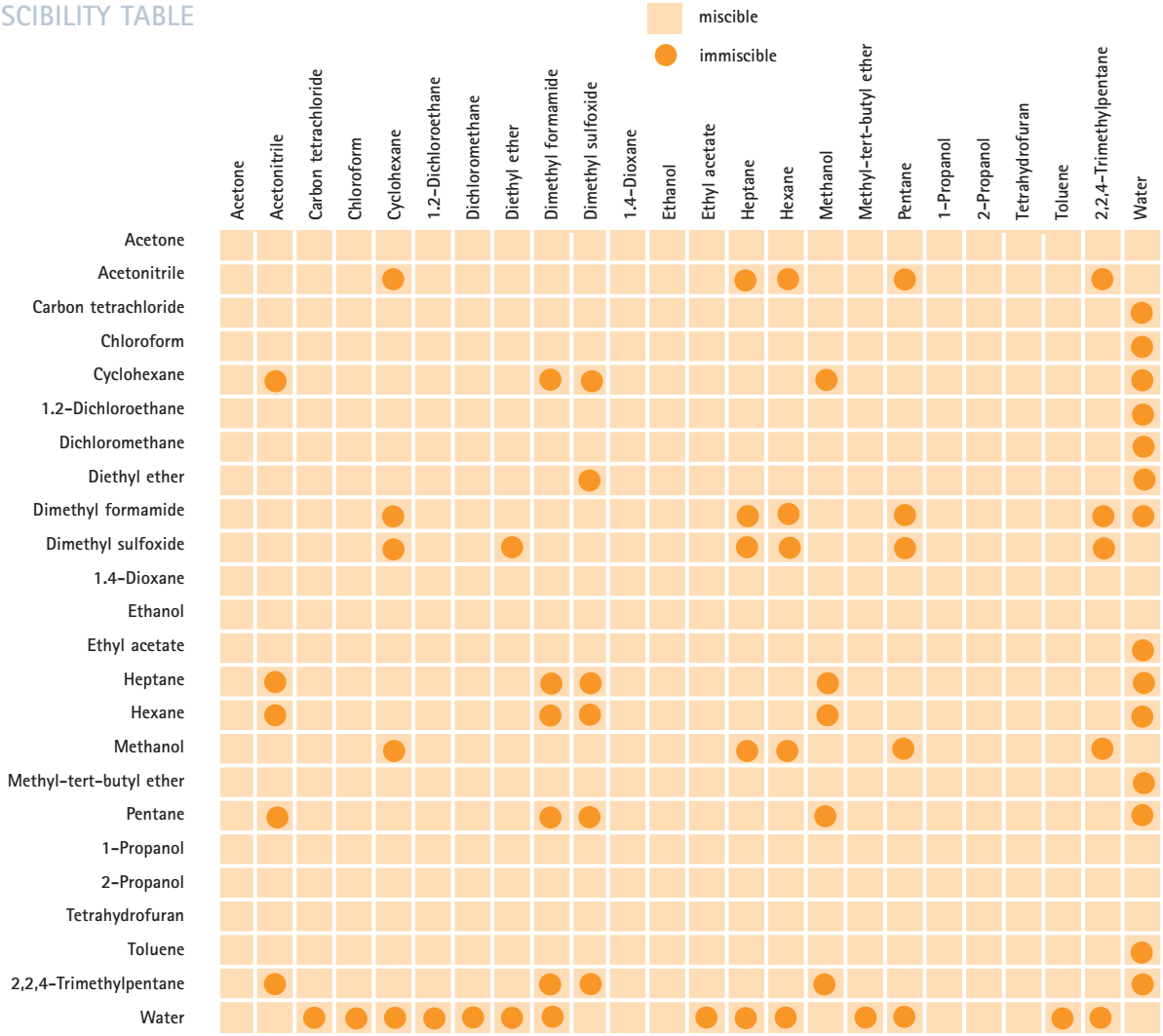


NMR: PROTON CHEMICAL SHIFTS

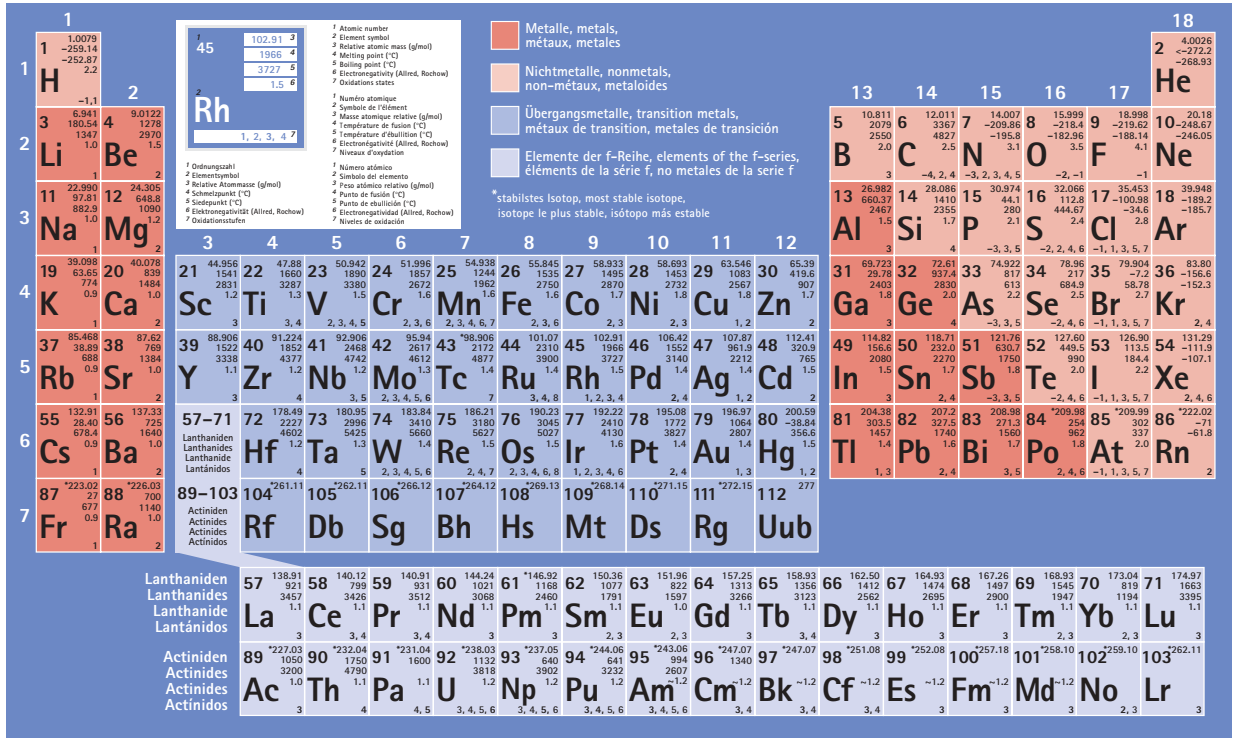


*The chemical shifts of these groups are concentration-dependent and are shifted to lower ppm values in more dilute solutions.

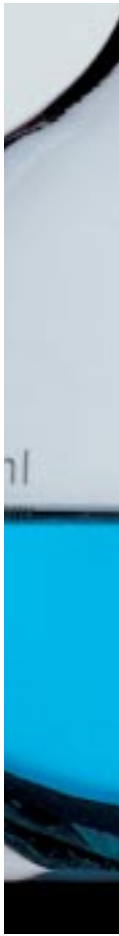
MISCIBILITY TABLE



	Media	Melting point (°C)	Boiling point (°C)	Working range (°C)	Flash point (°C)	Remarks
	Water	0	100	0-80	- within the stated range	Ideal
822329	Ethylene glycol	-12	198	-10-180	111	Flammable, difficult to remove from equipment
107742	Silicon oil	-60	-	20-250	300	Becomes viscid at lower temperatures - noncorrosive
808245	Triethylene glycol	-7	287	0-250	156	Water-soluble, stable
818709	Glycerol	18	290	20-260	160	Water-soluble, nontoxic, viscid
107162	Paraffin, liquid	-	300-500	20-200	230	Flammable
107160	Paraffin viscious	-	300-500	20-200	230	Flammable
106900	Oil bath filling	-5	-	0-250	300	Flammable
115265	Heating bath fluid	-40	-	0-170	280	Miscible with water, nontoxic
105061	Potassium nitrate (51.3%)	219	-	230-500	-	Stable in air, strong oxidizing agent, nonflammable
106535	Sodium nitrate (48.7%)					
106482	Sodium hydroxide (40%)	167	-	200-800	-	Corrosive and harmful
105032	Potassium hydroxide (60%)		-		-	


1 Atomic number
2 Element symbol
3 Relative atomic mass (g/mol)
4 Melting point (°C)
5 Boiling point (°C)
6 Electronegativity (Allred, Rochow)
7 Oxidations states
1 Numéro atomique
2 Symbole de l'élément
3 Masse atomique relative (g/mol)
4 Température de fusion (°C)
5 Température d'ébullition (°C)
6 Electronégativité (Allred, Rochow)
7 Niveaux d'oxydation
1 Número atómico
2 Símbolo del elemento
3 Peso atómico relativo (g/mol)
4 Punto de fusión (°C)
5 Punto de ebullición (°C)
6 Electronegatividad (Allred, Rochow)
7 Niveles de oxidación
1 Ordnungszahl
2 Elementsymbol
3 Relative Atommasse (g/mol)
4 Schmelzpunkt (°C)
5 Siedepunkt (°C)
6 Elektronegativität (Allred, Rochow)
7 Oxidationsstufen
Metalle, metals, métaux, metales
Nichtmetalle, nonmetals, non-métaux, metaloides
Übergangsmetalle, transition metals, métaux de transition, metales de transición
Elemente der f-Reihe, elements of the f-series, éléments de la série f, no metales de la serie f
*stabilstes Isotop, most stable isotope, isotope le plus stable, isótopo más estable
Lanthaniden Lanthanides Lanthanide Lantánidos
Actiniden Actinides Actinides Actínidos
57–71
89–103

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W. xxxxx.x 03/05

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