Lab Tools

Tables for laboratory use

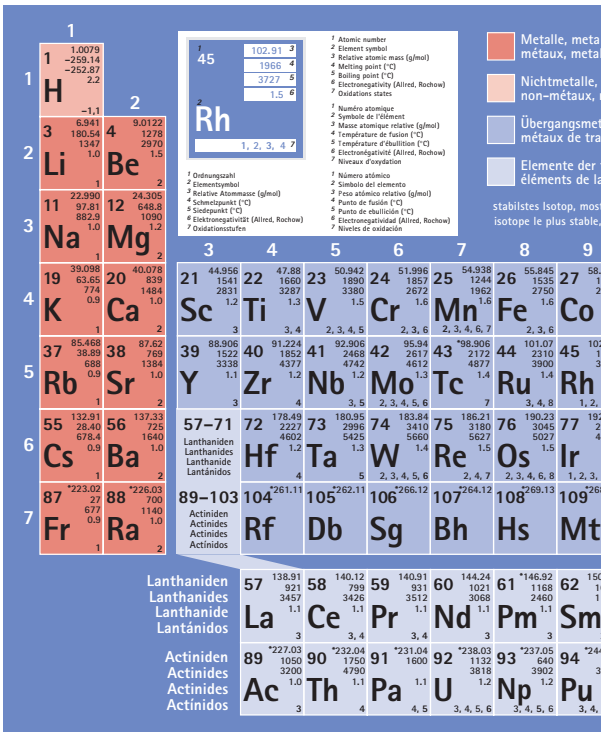
MERCK

Merck at a glance

- Two major business sectors - Pharmaceuticals and Chemicals
- Approximately 33.000 employees in 60 countries
- Total revenues in 2008: EUR 7.558 million
- Headquarters: Darmstadt / Germany
- The world´s oldest pharmaceutical and chemical company, with roots dating back to 1668
- Merck KGaA is listed on the Frankfurter Stock Exchange and is a DAX® 30 company
- Around 30 % of the total capital is publicly trated. The Merck family, indirectly holds around 70 %
- Merck invests in R&D: Pharmaceuticals business sector: 20 % of sale Chemicals business sector: 6.7 % of sales

For more information, please visit our website
www.merck-chemicals.com

Periodic table of the elements



ls,
les

nonmetals,
metaloides

talle, transition metals,
nsition, metales de transición

f-Reihe, elements of the f-series,
a série f, no metales de la serie f

t stable isotope,
isótopo más estable

18
2 4.0026 <-272.2 -268.93 He

13	14	15	16	17
5 10.811 2079 2550 2.0 B 3	6 12.011 3367 4827 2.5 C −4, 2, 4	7 14.007 −209.86 −195.8 3.1 N −3, 2, 3, 4, 5	8 15.999 −218.4 −182.96 3.5 O −2, −1	9 18.998 −219.62 −188.14 4.1 F −1
13 26.982 660.37 2467 1.5 Al 3	14 28.086 1410 2355 1.7 Si 4	15 30.974 44.1 280 2.1 P −3, 3, 5	16 32.066 112.8 444.67 2.4 S −2, 2, 4, 6	17 35.453 −100.98 −34.6 2.8 Cl −1, 1, 3, 5, 7
31 69.723 *29.78 2403 1.8 Ga 3	32 72.61 937.4 2830 2.0 Ge 4	33 74.922 817 613 2.2 As −3, 3, 5	34 78.96 217 684.9 2.5 Se −2, 4, 6	35 79.904 −7.2 58.78 2.7 Br −1, 1, 3, 5, 7
49 114.82 156.6 2080 1.5 In 3	50 118.71 232.0 2270 1.7 Sn 2, 4	51 121.76 630.7 1750 1.8 Sb −3, 3, 5	52 127.60 449.5 990 2.0 Te −2, 4, 6	53 126.90 113.5 184.4 2.2 I −1, 1, 3, 5, 7
81 204.38 303.5 1457 1.4 Tl 1, 3	82 207.2 327.5 1740 1.6 Pb 2, 4	83 208.98 271.3 1560 1.7 Bi 3, 5	84 *209.98 254 962 1.8 Po 2, 4, 6	85 *209.99 302 337 2.0 At −1, 1, 3, 5, 7

10	11	12
28 58.693 1453 2732 1.8 Ni 2, 3	29 63.546 1083 2567 1.8 Cu 1, 2	30 65.39 419.6 907 1.7 Zn 2
46 106.42 1552 3140 1.4 Pd 2, 4	47 107.87 961.9 2212 1.4 Ag 1, 2	48 112.41 320.9 765 1.5 Cd 2
78 195.08 1772 3827 1.4 Pt 2, 4	79 196.97 1064 2807 1.4 Au 1, 3	80 200.59 −38.84 356.6 1.5 Hg 1, 2
110 *271.15 Ds	111 *272.15 Rg	112 277 Cn

86	*222.02 −71 −61.8 Rn 2

63	64	65	66	67	68	69	70	71
151.96 822 1597 1.0 Eu 2, 3	157.25 1313 3266 1.1 Gd 3	158.93 1356 3123 1.1 Tb 3, 4	162.50 1412 2562 1.1 Dy 3	164.93 1474 2695 1.1 Ho 3	167.26 1497 2900 1.1 Er 3	168.93 1545 1947 1.1 Tm 2, 3	173.04 819 1194 1.1 Yb 2, 3	174.97 1663 3395 1.1 Lu 3
*243.06 994 2607 ~1.2 Am 3, 4, 5, 6	*247.07 1340 ~1.2 Cm 3, 4	*247.07 ~1.2 Bk 3, 4	*251.08 ~1.2 Cf 3, 4	*252.08 ~1.2 Es 3	*257.18 ~1.2 Fm 3	*258.10 ~1.2 Md 3	*259.10 No 2, 3	*262.11 Lr 3

Chemicals

Performance & Life Science Chemicals

- Focus on specialty chemicals solutions for cosmetic, pharmaceutical, biopharmaceutical and biotech applications
- Focus on effects pigments for cosmetics, coating, plastics and printing, food and pharma
- Laboratory business

Liquid Crystals

- Focus on innovation in display technologies to sustain market leadership
- Liquid Crystals, OLEDs, materials for solar cells

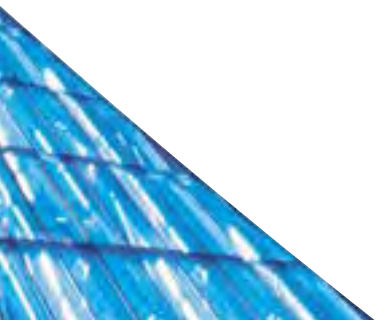
Pharmaceuticals

Merck Serono

- Focus on specialist and innovative prescription drugs
- Oncology, Neurodegenerative Diseases, Autoimmune and Inflammatory Diseases, Fertility, Endocrinology, CardioMetabolic Care

Consumer Health Care

- Focus on over-the-counter pharmaceutical products for four health themes: Mobility, Everyday Health Protection, Woman´s and Children´s Health, Cough and Cold



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Ru
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Au
Hg
Bh
Hs
Mt
Uun
Uuu
Uub
Gd

Chemical and physical properties of elements and inorganic compounds

Table of elements

Element name	Symbol	Ordinal-number	Atomic mass**	Density 20° 4°	Melting-point [°C]
Actinium	Ac	89	227.028	10.1	1050
Aluminium	Al	13	26.98154	2.70	660.37
Americium	Am	95	(243)	11.7	994 ± 4
Antimony	Sb	51	121.76	6.68	630.74
Argon	Ar	18	39.948	*1.784	– 189.2
Arsenic	As	33	74.9216	5.73	817 (28 bar)
Astatine	At	85	(210)	–	302
Barium	Ba	56	137.33	3.7	725
Berkelium	Bk	97	(247)	–	–
Beryllium	Be	4	9.01218	1.86	1278 ± 5
Bismuth	Bi	83	208.9804	9.80	271.3
Boron	B	5	10.81	2.34	2300
Bromine	Br	35	79.904	3.14	– 7.2
Cadmium	Cd	48	112.41	8.64	320.9
Cesium	Cs	55	132.9054	1.90	28.40 ± 0.01
Calcium	Ca	20	40.078	1.55	839 ± 2
Californium	Cf	98	(251)	–	–
Carbon	C	6	12.011	2.25	~ 3550
Cerium	Ce	58	140.115	6.8	798 ± 3
Chlorine	Cl	17	35.4527	*3.214	– 100.98
Chromium	Cr	24	51.996	7.19	1857 ± 20
Cobalt	Co	27	58. 9332	8.83	1495
Copper	Cu	29	63.546	8.93	1083.4 ± 0.2
Curium	Cm	96	(247)	–	1340 ± 40
Dysprosium	Dy	66	162.50	8.54	1409
Einsteinium	Es	99	(254)	–	–
Erbium	Er	68	167.26	9.05	1522
Europium	Eu	63	151.96	5.26	822 ± 5
Fermium	Fm	100	(257)	–	–
Fluorine	F	9	18.9984	*1.70	– 219.62
Francium	Fr	87	(223)	–	(27)
Gadolinium	Gd	64	157.25	7.90	1311 ± 1
Gallium	Ga	31	69.723	6.0	29.78
Germanium	Ge	32	72.61	5.36	937.4
Gold	Au	79	196.966	19.3	1064.4
Hafnium	Hf	72	178.49	13.3	2227 ± 20
Helium	He	2	4.00260	*0.178	– 272.2
Holmium	Ho	67	164.93	8.80	1470
Hydrogen	H	1	1.00794	*0.0899	– 259.14
Indium	In	49	114.82	7.31	156.61
Iod	I	53	126.9045	4.94	113.5
Iridium	Ir	77	192.22	22.6	2410
Iron	Fe	26	55.847	7.86	1535
Krypton	Kr	36	83.80	*3.708	– 156.6
Lanthanum	La	57	138.9055	6.1	920 ± 5
Lawrencium	Lr	103	(260)	–	–
Lead	Pb	82	207.2	11.4	327.5
Lithium	Li	3	6.941	0.53	180.54
Lutetium	Lu	71	174.967	9.84	1656 ± 5
Magnesium	Mg	12	24.305	1.74	648.8 ± 0,5
Manganese	Mn	25	54.93805	7.3	1244 ± 3

* Gases in [g/l] at °C and normal pressure

** longest-lived isotope in brackets

*** Earth's crust

Boiling-point [°C]	Occurrence of the elements*** [%]	Atomic radiuses [pm]	Ionic radiuses [pm]	Electro-negativity
3200 ± 300	–	–	118 (III)	1.00
2467	8.1	143	51 (III)	1.47
2607	–	–	107 (III), 92 (IV)	~ 1.2
1750	0.0001	145	76 (III), 62 (V)	1.82
– 185.7	–	191	–	–
613 (sub.)	0.0005	125	58 (III), 46 (V)	2.20
337	–	–	62 (VII)	1.96
1640	0.025	217	134 (II)	0.97
–	–	–	–	~ 1.2
2970 (5 mm)	0.0006	112	35 (II)	1.47
1560 ± 5	0.00002	155	96 (III), 74 (V)	1.67
2550 (sub.)	0.0003	97	23 (III)	2.01
58.78	0.00016	119	196 (–I), 47 (V), 39 (VII)	2.74
765	0.000015	149	97 (II)	1.46
678.4	0.0007	262	167 (I)	0.86
1484	3.6	196	99 (II)	1.04
–	–	–	–	~ 1.2
4827	0.03	77	16 (IV)	2.50
3257	0.0046	182	107 (III), 94 (IV)	1.06
– 34.6	0.031	107	181 (–I), 34 (V), 27 (VII)	2.83
2672	0.02	125	63 (III), 52 (VI)	1.56
2870	0.0023	125	72 (II), 63 (III)	1.70
2567	0.007	128	96 (I), 72 (II)	1.75
–	–	–	–	~ 1.2
2335	0.00045	–	92 (III)	1.10
–	–	–	–	~ 1.2
2510	0.00025	–	89 (III)	1.11
1597	0.00011	–	124 (II), 98 (III)	1.01
–	–	–	–	~ 1.2
– 188.14	0.03	71	133 (–I), 8 (VII)	4.10
(677)	–	–	180 (I)	0.86
3233	0.00064	–	97 (III)	1.11
2403	0.0015	–	62 (III)	1.82
2830	0.0007	–	73 (II), 53 (IV)	2.02
2807	0.00000005	144	137 (I), 85 (III)	1.42
4602	0.00045	–	78 (IV)	1.23
– 268.934	0.00000003	145	–	–
2720	0.00012	–	91 (III)	1.10
– 252.87	0.14	46	154 (–I)	2.20
2080	0.00001	–	81 (III)	1.49
184.35	0.00003	136	220 (–), 62 (V), 50 (VII)	2.21
4130	0.00000001	–	68 (IV)	1.55
2750	5.0	124	74 (II), 64 (III)	1.64
– 152(3)	–	–	–	–
3454	0.0018	–	114 (III)	1.08
–	–	–	–	–
1740	0.0016	175	215 (–II), 120 (II), 84 (IV)	1.55
1347	0.0065	152	68 (I)	0.97
3315	0.00008	–	85 (III)	1.14
1090	0.21	160	66 (II)	1.23
1962	0.1	118	80 (II), 66 (III), 60 (IV), 46 (VII)	1.60

Table of elements

Element name	Symbol	Ordinal-number	Atomic mass**	Density 20° 4°	Melting-point [°C]
Mendelevium	Md	101	(258)	–	–
Mercury	Hg	80	200.59	13.55	– 38.87
Molybdenum	Mo	42	95.94	10.2	2617
Neodymium	Nd	60	144.24	7.0	1010
Neon	Ne	10	20.1797	*0.90	– 248.7
Neptunium	Np	93	237.0482	19.5	640 ± 1
Nickel	Ni	28	58.69	8.90	1453
Niobium	Nb	41	92.9064	8.5	2468 ± 10
Nitrogen	N	7	14.0067	*1.251	– 209.86
Nobelium	No	102	(259)	–	–
Osmium	Os	76	190.23	22.5	3045 ± 30
Oxygen	O	8	15.9994	*1.429	– 218.4
Palladium	Pd	46	106.42	12.0	1552
Phosphorous, white	P	15	30.97376	1.83	44.1
Platinum	Pt	78	195.08	21.45	1.772
Plutonium	Pu	94	(244)	19.7	641
Polonium	Po	84	(209)	9.32	254
Potassium	K	19	39.0983	0.86	63.65
Praseodymium	Pr	59	140.908	6.7	931 ± 4
Promethium	Pm	61	(145)	–	~ 1080
Protactinium	Pa	91	231.036	–	< 1600
Radium	Ra	88	226.0254	~ 6	700
Radon	Rn	86	(222)	*9.96	– 71
Rhenium	Re	75	186.207	20.9	3180
Rhodium	Rh	45	102.905	12.4	1966 ± 3
Rubidium	Rb	37	85.4678	1.53	38.89
Ruthenium	Ru	44	101.07	12.4	2310
Samarium	Sm	62	150.36	7.5	1072 ± 5
Scandium	Sc	21	44.9559	3.0	1539
Selenium	Se	34	78.96	4.8	217
Silver	Ag	47	107.8682	10.5	961.93
Silicium	Si	14	28.0855	2.4	1410
Sodium	Na	11	22.98977	0.97	97.81 ± 0.03
Strontium	Sr	38	87.62	2.6	769
Sulphur	S	16	32.066	2.0	112.8
Tantalum	Ta	73	180.9479	16.7	2996
Technetium	Tc	43	(97)	11.5	2172
Tellurium	Te	52	127.60	6.2	449.5 ± 0.3
Terbium	Tb	65	158.92534	8.3	1360 ± 4
Thallium	Tl	81	204.3833	11.85	303.5
Thorium	Th	90	232.0381	11.7	1750
Thulium	Tm	69	168.9342	9.33	1545 ± 15
Tin	Sn	50	118.71	7.3	231.9681
Titanium	Ti	22	47.88	4.51	1660 ± 10
Tungston	W	74	183.84	19.30	3410 ± 20
Uranium	U	92	238.029	19.1	1132.3 ± 0.8
Vanadium	V	23	50.9415	6.1	1890 ± 10
Xenon	Xe	54	131.29	*5.89	– 111.9
Ytterbium	Yb	70	173.04	6.5	824 ± 5
Yttrium	Y	39	88.90585	4.5	1523 ± 8
Zinc	Zn	30	65.39	7.2	419.58
Zirkonium	Zr	40	91.224	6.5	1852 ± 2

* Gases in [g/l] at °C and normal pressure

** longest-lived isotope in brackets

*** Earth's crust

Boiling-point [°C]	Occurrence of the elements***	Atomic radiuses [%]	Ionic radiuses [pm]	Electro-negativity
–				~ 1.2
356.58	0.00005	150	110 (II)	1.44
4612	0.0015	–	70 (IV), 62 (VI)	1.30
3127	0.0024	–	104 (III)	1.07
– 246.05	–	–	–	–
3902	–	–	110 (III), 95 (IV), 71 (VII)	1.22
2732	0.008	124	69 (II)	1.75
4742	0.0024	–	74 (IV), 69 (VI)	1.23
– 195.8	0.0046	71	16 (III), 13 (V)	3.07
–	–	–	–	–
5027 ± 100	0.00000001	–	67 (IV), 69 (VI)	1.52
– 182.962	46.6	65	132 (–II), 10 (VI)	3.50
3140	0.0000001	–	80 (II), 65 (IV)	1.35
280	1.2	–	44 (III), 35 (V)	2.06
3827	0.00000005	138	80 (II), 65 (IV)	1.44
3232	–	–	108 (III), 93 (IV)	1.22
962	–	–	–	1.76
774	2.6	231	133 (I)	0.91
3212	0.00055	–	106 (III), 92 (IV)	1.07
–	–	–	106 (III)	1.07
–	–	–	113 (III), 98 (IV), 89 (V)	1.14
1140	–	–	143 (II)	0.97
– 61.8	–	–	–	–
–	0.00000001	–	72 (IV), 56 (VII)	1.46
3727 ± 100	0.00000001	–	68 (III)	1.45
688	0.03	243	147 (I)	0.89
3000	0.00000001	–	67 (IV)	1.42
1778	0.00065	–	100 (III)	1.07
2832	0.0005	–	81 (III)	1.20
684.9 ± 1.0	0.000009	–	191 (–II), 83 (III), 50 (IV), 42 (VI)	2.48
2212	0.00001	144	126 (I), 89 (II)	1.42
2355	27.7	117	221 (–IV), 42 (IV)	1.74
882.9	2.8	186	97 (I)	1.01
1384	0.03	–	112 (II)	0.99
444.674	0.05	104	174 (–II), 37 (IV), 30 (VI)	2.44
5425 ± 100	0.00021	–	68 (V)	1.33
4877	–	–	56 (VII)	1.36
989.8 ± 3.8	0.00000002	–	211 (–II), 70 (IV), 56 (VI)	2.01
3041	0.00009	–	93 (III), 89 (IV)	1.10
1457 ± 10	0.00006	–	147 (I), 95 (III)	1.44
ca. 4790	0.0012	–	102 (IV)	1.11
1727	0.00002	–	87 (III)	1.11
2270	0.004	140	294 (–IV), 93 (II), 71 (IV)	1.72
3287	0.45	–	80 (II), 76 (III), 68 (IV)	1.32
5660	0.007	136	70 (IV), 62 (VI)	1.40
3818	0.0004	138	97 (IV), 80 (VI)	1.22
3380	0.015	–	88 (II), 74 (III), 63 (IV), 59 (V)	1.45
– 107.1 ± 3	–	–	–	–
1193	0.00027	–	86 (III)	1.06
3337	0.0028	–	92 (III)	1.11
907	0.013	133	74 (II)	1.66
4377	0.022	–	79 (IV)	1.22

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 some nonmetals (alkaline solution)

Red ⇄ Ox + e	e° [Volt]
$Te^{2-} \rightleftarrows Te + 2e$	– 1.14
$Se^{2-} \rightleftarrows Se + 2e$	– 0.92
$S^{2-} \rightleftarrows S + 2e$	– 0.48

Red ⇄ Ox + e	e° [Volt]
$2\ I^- \rightleftarrows I_2 + 2e$	+ 0.54
$2\ Br^- \rightleftarrows Br_2 + 2e$	+ 1.07
$2\ Cl^- \rightleftarrows Cl_2 + 2e$	+ 1.36
$2\ F^- \rightleftarrows F_2 + 2e$	+ 2.87

Covalent single-bond radiuses (in pm)

Element	Radius [pm]
H*	28
C	77
Si	117
Ge	122
Sn	140
N	70
P	110
As	121
Sb	141

Element	Radius [pm]
O	66
S	104
Se	117
Te	137
F	64
Cl	99
Br	114
I	133

* Determined from H–X bond distances

Solutions – aqueous systems

General formulas for mixing liquids

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

With:

A = weight of the original liquid — a = its content in % by weight
B = weight of the diluent — b = its content in % by weight
C = weight of the prepared mixture — c = its content in % by weight
For water as diluent: b = 0

Example

10 l of battery sulfuric acid with a density of

$D\frac{20^\circ}{4^\circ}$ = 1.28. 1.28 is required.

Available: concentrated sulfuric acid with a density of $D\frac{20^\circ}{4^\circ}$ = 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:

$D\frac{20^\circ}{4^\circ}$ = 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 $D\frac{20^\circ}{4^\circ}$ = 1.84 must be added to 7.895 kg (= l) of water to yield 10 l of battery acid with a density of $D\frac{20^\circ}{4^\circ}$ = 1.28.

Convention 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

With Merckoquant® Total Hardness strips you can easily and quickly check the water hardness in the following ranges:
< 3 – 21°d
< 5 – 25°d
soft – medium - hard

Mixture rules

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. 32) 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 $D^{20°}_{4°}$ = 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 %)

Solubility of inorganic compounds in water

	Name	Cat. No.	Formula
A	Aluminum ammonium sulfate dodecahydrate	101031	$AlNH_4(SO_4)_2 \cdot 12H_2O$
	Aluminum chloride hexahydrate	101084	$AlCl_3 \cdot 6H_2O$
	Aluminum nitrate nonahydrate	101063	$Al(NO_3)_3 \cdot 9H_2O$
	Aluminum potassium sulfate dodecahydrate	101047	$AlK(SO_4)_2 \cdot 12H_2O$
	Aluminum sulfate octadecahydrate	101102	$Al_2(SO_4)_3 \cdot 18H_2O$
	Ammonium bromide	101125	NH_4Br
	Ammonium chloride	101145	NH_4Cl
	Ammonium dihydrogen phosphate	101126	$NH_4H_2PO_4$
	Ammonium hydrogen carbonate	101131	NH_4HCO_3
	di-Ammonium hydrogen phosphate	101207	$(NH_4)_2HPO_4$
	Ammonium iron(II) sulfate hexahydrate	103792	$(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$
	Ammonium monovanadate	101226	NH_4VO_3
	Ammonium nitrate	101188	NH_4NO_3
	Ammonium sulfate	101217	$(NH_4)_2SO_4$
	Ammonium thiocyanate	101213	NH_4SCN
	Antimony(III) chloride	107838	$SbCl_3$
B	Barium acetate	101704	$Ba(CH_3COO)_2$
	Barium chloride dihydrate	101719	$BaCl_2 \cdot 2H_2O$
	Barium hydroxide octahydrate	101737	$Ba(OH)_2 \cdot 8H_2O$
	Barium nitrate	101729	$Ba(NO_3)_2$
	di-Boron trioxide	100163	B_2O_3
	Boric acid	100165	H_3BO_3
C	Cadmium sulfate hydrate	102027	$3CdSO_4 \cdot 8H_2O$
	Calcium acetate	109325	$Ca(CH_3COO)_2$
	Calcium chloride dihydrate	102382	$CaCl_2 \cdot 2H_2O$
	Calcium nitrate tetrahydrate	102121	$Ca(NO_3)_2 \cdot 4H_2O$
	Calcium sulfate dihydrate	102161	$CaSO_4 \cdot 2H_2O$
	Cesium chloride	102038	$CsCl$
	Cesium nitrate	102856	$CsNO_3$
	Chromium(VI) oxide	100229	CrO_3
	Cobalt chloride	802540	$CoCl_2$
	Cobalt chloride hexahydrate	102539	$CoCl_2 \cdot 6H_2O$
	Cobalt nitrate hexahydrate	102536	$Co(NO_3)_2 \cdot 6H_2O$
	Cobalt sulfate heptahydrate	102556	$CoSO_4 \cdot 7H_2O$
	Copper(I) chloride	102739	$CuCl$
	Copper(II) chloride dihydrate	102733	$CuCl_2 \cdot 2H_2O$
	Copper(II) nitrate trihydrate	102753	$Cu(NO_3)_2 \cdot 3H_2O$
	Copper(II) sulfate pentahydrate	102790	$CuSO_4 \cdot 5H_2O$
	Copper sulfate	102791	$CuSO_4$
I	Iron(III) chloride	803945	$FeCl_3$
	Iron(III) chloride hexahydrate	103943	$FeCl_3 \cdot 6H_2O$

in relation to temperature

Solubility in g/100 g H_2O at °C						Content of the total solution at 20 °C [%]	Density of the total solution at 20 °C [%]
0	20	40	60	80	100		
2.6	6.6	12.4	21.1	35.2	109.2 (95 °C)	6.2	1.0459 (15.5 °C)
44.9	45.6	46.3	47.7	47.7	–	31.3	–
61.0	75.4	89.0	108.0	–	–	43.0	–
2.96	6.01	13.6	33.3	72.0	109.0 (90 °C)	5.67	1.053
31.2	36.4	45.6	58.0	73.0	89.0	26.7	1.308
60.6	75.5	91.1	107.8	126.7	145.6	43.9	–
29.7	37.6	46.0	55.3	65.6	77.3	27.3	1.075
22.7	36.8	56.7	82.9	120.7	174.0	26.9	–
11.9	21.2	36.6	59.2	109.2	355.0	17.5	1.07
57.5	68.6	81.8	97.6	(115.5)	–	40.70	1.3436 (14.5 °C)
17.8	26.9	38.5	53.4	72.0	–	21.2	1.18
–	4.8	13.2	–	–	–	–	–
118.5	187.7	283.0	415.0	610.0	1000.0	65.0	1.308
70.4	75.4	81.2	87.4	94.1	102.0	43.0	1.247
115.0	163.0	235.0	347.0	–	–	62.0	–
601.6	931.5	1368.0	4531.0	–	–	90.3	–
58.0	72.0	79.0	74.0	74.0	74.0	–	–
30.7	35.7	40.8	46.4	52.5	58.7	26.3	1.28
1.5	3.5	8.2	21.0	–	–	3.4	1.04
5.0	9.1	14.4	20.3	27.2	34.2	8.3	1.069
1.1	2.2	4.0	6.2	9.5	15.7	2.15	–
2.7	5.04	8.7	14.8	23.6	39.7	4.8	1.015
75.5	76.7	79.3	82.0	84.6	–	43.4	1.616
37.4	34.7	33.2	32.7	33.5	29.7	–	–
–	–	128.1	136.8	147.0	159.0	–	–
101.0	129.4	196.0	–	–	–	56.4	–
0.18	0.20	0.21	0.20	0.19	0.16	0.20	1.001
161.0	187.0	208.0	230.0	250.0	271.0	–	–
9.3	23.0	47.2	83.8	134.0	197.0	–	–
163.0	166.7	171.0	176.0	189.0	199.0	62.50	1.7100 (16.5 °C)
74.5	91.9	–	–	–	–	47.9	1.52
–	62.35	68.6	78.3	–	–	38.4	1.49
–	–	–	–	525.1	537.0	–	–
41.9	53.6	69.5	–	–	–	34.9	–
–	1.5 (25 °C)	–	–	–	–	1.497 (25 °C)	–
70.65	77.0	83.8	91.2	99.2	107.9	43.5	1. 55
–	–	160.0	179.0	208.0	(257.0)	–	–
14.8	20.8	29.0	39.1	53.6	73.6	17.2	1.1965
25.5	36.2	48.0	60.0	70.0	83.0	–	–
25.5	36.3	49.9	–	–	–	26.6	–
83.5	100.0	126.0	169.5	–	–	50.0	–

Solubility of inorganic compounds in water

	Name	Cat. No.	Formula
I	Iron(II) chloride tetrahydrate	103861	$FeCl_2 \cdot 4H_2O$
	Iron(II) sulfate heptahydrate	103965	$FeSO_4 \cdot 7H_2O$
	Iron(II) sulfate monohydrate	103967	$FeSO_4 \cdot H_2O$
L	Lead chloride	807383	$PbCl_2$
	Lead nitrate	107398	$Pb(NO_3)_2$
	Lithium bromide	105669	LiBr
	Lithium carbonate	105680	Li_2CO_3
	Lithium chloride monohydrate	105677	$LiCl \cdot H_2O$
	Lithium iodide	818287	LiI
	Lithium nitrate	112230	$LiNO_3$
	Lithium sulfate monohydrate	105694	$LiSO_4 \cdot H_2O$
M	Magnesium chloride hexahydrate	105833	$MgCl_2 \cdot 6H_2O$
	Magnesium nitrate hexahydrate	105853	$Mg(NO_3)_2 \cdot 6H_2O$
	Magnesium sulfate heptahydrate	105886	$MgSO_4 \cdot 7H_2O$
	Manganese(II) chloride tetrahydrate	105927	$MnCl_2 \cdot 4H_2O$
	Manganese(II) chloride dihydrate	105934	$MnCl_2 \cdot 2H_2O$
	Manganese(II) sulfate monohydrate	105941	$MnSO_4 \cdot H_2O$
	Mercury(II) bromide	104421	$HgBr_2$
	Mercury(II) chloride	104419	$HgCl_2$
N	Nickel chloride hexahydrate	106717	$NiCl_2 \cdot 6H_2O$
	Nickel nitrate hexahydrate	106721	$Ni(NO_3)_2 \cdot 6H_2O$
	Nickel sulfate hexahydrate	106727	$Ni_2SO_4 \cdot 6H_2O$
P	Potassium acetate	104820	KCH_3COO
	Potassium bromate	104912	$KBrO_3$
	Potassium bromide	104905	KBr
	Potassium carbonate	104928	K_2CO_3
	Potassium chlorate	104944	$KClO_3$
	Potassium chloride	104936	KCl
	Potassium chromate	104952	K_2CrO_4
	Potassium cyanide	104967	KCN
	Potassium dichromate	104864	K_2Cr_2O7
	Potassium dihydrogen phosphate	104873	KH_2PO_4
	Potassium disulfite	105057	$K_2S_2O_5$
	Potassium hexachloroplatinate(IV)	119238	$K_2[Pt(Cl)_6]$
	Potassium hexacyanoferrate(II) trihydrate	104984	$K_4[Fe(CN)_6] \cdot 3H_2O$
	Potassium hexacyanoferrate(III)	104973	$K_3[Fe(CN)_6]$
	Potassium hydrogen carbonate	104854	$KHCO_3$
	di-Potassium hydrogen phosphate trihydrate	105099	$K_2HPO_4 \cdot 3H_2O$
	di-Potassium hydrogen phosphate	105104	K_2HPO_4
	Potassium hydrogen sulfate	104885	$KHSO_4$
	Potassium hydroxide monohydrate	105002	$KOH \cdot H_2O$

in relation to temperature

Solubility in g/100 g H_2O at °C						Content of the total solution at 20 °C [%]	Density of the total solution at 20 °C [%]
0	20	40	60	80	100		
–	–	–	(90.5) (56 °C)	100.0	107.5	–	–
15.6	26.6	40.3	47.6	–	–	21.0	1.225
–	–	–	–	43.8	(31.6)	–	–
0.67	0.99	1.45	1.98	2.6	3.3	0.98	1.007
36.4	52.2	69.4	88.0	107.5	127.3	34.3	1.40
143.0	177.0	205.0	224.0	245.0	266.0	–	–
–	1.3	–	–	–	–	1.31	–
–	82.8	90.4	100.0	113.0	(127.5)	45.3	1.29
151.0	165.0	180.0	–	–	480.0	–	–
48.0	76.0	–	–	–	227.0	–	–
36.2	34.8	33.5	32.3	31.5	31.0	25.6	1.23
52.8	54.6	57.5	60.7	65.9	72.7	35.3	1.331
63.9	70.1	81.8	93.7	–	–	41.2	1.388 (25 °C)
–	35.6	45.4	–	–	–	26.25	1.31
63.6	73.6	88.7	(106.0) (58.1 °C)	–	–	42.4	1.499
–	–	–	–	110.5	115.0	–	–
–	–	60.0	58.6	45.5	35.5	–	–
–	0.62 (25 °C)	(0.96)	1.7	2.8	4.9	0.62 (25 °C)	–
4.29	6.6	9.6	13.9	24.2	54.1	6.2	1.052
51.7	55.3	–	–	–	–	35.6	1.46
79.2	94.1	118.8	–	–	–	48.5	–
–	–	–	57.0	–	–	–	–
217.0	256.0	323.0	350.0	–	380.0	–	–
3.1	6.8	13.1	22.0	33.9	49.7	6.4	1.048
54.0	65.8	76.1	85.9	95.3	104.9	39.7	1.370
106.0	110.0	117.0	127.0	140.0	156.0	–	–
3.3	7.3	14.5	25.9	39.7	56.2	6.8	1.042
28.2	34.2	40.3	45.6	51.0	56.2	25.5	1.174
59.0	63.7	67.0	70.9	75.1	79.2	38.9	1.378
(63.0)	71.6 (25 °C)	–	81.0 (50 °C)	(95.0) (75 °C)	122.0 (103.3 °C)	41.73 (25 °C)	–
4.7	12.5	26.3	45.6	73.0	103.0	11.1	1.077
14.3	22.7	33.9	48.6	68.0	–	18.5	–
27.5	44.9	63.9	85.0	108.0	133.0	30.99	–
0.74	1.1	1.7	2.6	3.8	5.2	–	–
15.0	28.9	42.7	56.0	68.9	(82.7)	22.4	1.16
29.9	46.0	59.5	70.9	81.8	91.6	31.5	1.18
22.6	33.3	45.3	60.0	–	–	24.98	1.18
–	159.0	212.5	– (50 °C)	– (75 °C)	–	61.4	–
–	–	–	266.0	–	–	–	–
36.3	51.4	67.3	–	–	121.6	33.95	–
–	–	136.4	147.0	160.0	178.0	–	–

Solubility of inorganic compounds in water

	Name	Cat. No.	Formula
P	Potassium iodate	105051	KIO_3
	Potassium iodide	105043	KI
	Potassium nitrate	105063	KNO_3
	di-Potassium oxalate monohydrate	105073	$K_2C_2O_4 \cdot H_2O$
	Potassium perchlorate	105076	$KClO_4$
	Potassium permanganate	105082	$KMnO_4$
	Potassium peroxodisulfate	105091	$K_2S_2O_8$
	Potassium sulfate	105153	K_2SO_4
	Potassium thiocyanate	105125	KSCN
	Rubidium chloride	107615	RbCl
S	Sodium acetate trihydrate	106267	$NaCH_3COO \cdot 3H_2O$
	Sodium bromide	106363	NaBr
	Sodium carbonate decahydrate	106391	$Na_2CO_3 \cdot 10H_2O$
	Sodium carbonate monohydrate	106386	$Na_2CO_3 \cdot H_2O$
	Sodium carbonate	106392	Na_2CO_3
	Sodium chlorate	106420	$NaClO_3$
	Sodium chloride	106404	NaCl
	Sodium dichromate dihydrate	106336	$Na_2Cr_2O_7 \cdot 2H_2O$
	Sodium dihydrogen phosphate dihydrate	106342	$NaH_2PO_4 \cdot 2H_2O$
	Sodium dihydrogen phosphate	106370	NaH_2PO_4
	tetra-Sodium diphosphate decahydrate	106591	$Na_4P_2O_7 \cdot 10H_2O$
	Sodium disulfite	106528	$Na_2S_2O_5$
	Sodium fluoride	106449	NaF
	Sodium hydrogen carbonate	106329	$NaHCO_3$
	di-Sodium hydrogen phosphate dodecahydrate	106579	$Na_2HPO_4 \cdot 12H_2O$
	di-Sodium hydrogen phosphate heptahydrate	106575	$Na_2HPO_4 \cdot 7H_2O$
	di-Sodium hydrogen phosphate dihydrate	106580	$Na_2HPO_4 \cdot 2H_2O$
	di-Sodium hydrogen phosphate	106586	Na_2HPO_4
	Sodium hydroxide monohydrate	106466	$NaOH \cdot H_2O$
	Sodium hydroxide	106498	NaOH
	Sodium iodate	106525	$NaIO_3$
	Sodium iodide	106523	NaI
	Sodium nitrate	106537	$NaNO_3$
	Sodium nitrite	106549	$NaNO_2$
	Sodium perchlorate monohydrate	106564	$NaClO_4 \cdot H_2O$
	tri-Sodium phosphate dodecahydrate	106578	$Na_3PO_4 \cdot 12H_2O$
	Sodium sulfate decahydrate	106648	$Na_2SO_4 \cdot 10H_2O$
	Sodium sulfate	106649	Na_2SO_4
	Sodium sulfite	106657	Na_2SO_3
	di-Sodium tetraborate	106310	$Na_2B_4O_7$
	Sodium thiosulfate pentahydrate	106516	$Na_2S_2O_3 \cdot 5H_2O$
	Silver nitrate	101512	$AgNO_3$
	Silver sulfate	101509	Ag_2SO_4

in relation to temperature

Solubility in g/100 g H_2O at °C						Content of the total solution at 20 °C [%]	Density of the total solution at 20 °C [%]
0	20	40	60	80	100		
4.7	8.1	12.9	18.5	24.8	32.3	7.5	1.064
127.8	144.5	161.0	176.2	191.5	208.0	59.1	1.71
13.3	31.7	63.9	109.9	169.0	245.2	24.1	1.16
–	35.9	–	–	–	–	26.4	–
0.76	1.7	3.6	7.2	13.4	22.2	1.7	1.008
2.8	6.4	12.6	22.4	–	–	6.0	1.04
0.18	0.5	1.1	–	–	–	0.468	–
7.3	11.1	14.8	18.2	21.3	24.1	10.0	1.0807
177.0	218.0	–	–	–	–	68.55	1.42
70.6	83.6	–	–	–	128.0	–	–
36.3	46.4	65.4	138.0 (58 °C)	– 65.9	– 72.7	31.7 35.3	1.17 1.331
–	–	–	118.0	118.3	121.2	–	–
6.86	21.7	–	–	–	–	17.8	1.1941
–	–	48.9	46.2	44.5	44.5	–	–
7.1	21.4	48.5	46.5	45.8	45.5	–	–
80.5	98.8	115.2	(138.0)	(167.0)	204.0	49.7	–
–	35.9	36.4	37.1	38.1	39.2	26.4	1.201
163.2	180.2	220.5	283.0	385.0	–	64.3	–
57.7	85.2	138.2	–	–	–	46.0	–
–	–	–	179.3	207.3	284.4	–	–
2.7	5.5	12.5	21.9	30.0	40.3	5.2	1.05
–	65.3	71.1	79.9	88.7	(100.0)	39.5	–
(3.6)	4.1	–	–	–	–	3.94	1.04
6.89	9.6	12.7	16.0	19.7	23.6	8.76	1.08
1.63	7.7	–	–	–	–	7.2	1.08
–	–	55.0	–	–	–	–	–
–	–	–	83.0	92.4	–	–	–
–	–	–	–	–	104.1	–	–
–	109.2	126.0	178.0	–	–	52.2	1.55
–	–	–	–	313.7	341.0	–	–
2.5	9.1	–	23.0	27.0	32.8	–	–
–	–	–	–	295.0	303.0	–	–
70.7	88.3	104.9	124.7	148.0	176.0	46.8	1.38
73.0	84.5	95.7	112.3	135.5	163.0	45.8	1.33
167.0	181.0	243.0	–	–	–	64.4	1.757
1.5	12.1	31.0	55.0	81.0	108.0	10.8	1.106
4.56	19.2	–	–	–	–	16.1	1.150
–	–	48.1	45.3	43.1	42.3	–	–
–	–	37.0	33.2	29.0	26.6	–	–
1.2	2.7	6.0	20.3	31.5	52.5	–	–
52.5	70.1	102.6	–	–	–	41.2	1.39
115.0	219.2	334.8	471.0	652.0	1024.0	68.6	2.18
0.57	0.79	0.98	1.15	1.3	1.5	0.75	–

Solubility of inorganic compounds in water

	Name	Cat. No.	Formula
S	Strontiumchlorid-Hexahydrat	107865	$SrCl_2 \cdot 6H_2O$
	Strontiumhydroxid-Octahydrat	107876	$Sr(OH)_2 \cdot 8H_2O$
	Strontiumnitrat	107872	$Sr(NO_3)_2$
T	Tin(II) chloride	818150	$SnCl_2$
Z	Zinc bromide	818631	$ZnBr_2$
	Zinc chloride	108816	$ZnCl_2$
	Zinc nitrate tetrahydrate	108833	$Zn(NO_3)_2 \cdot 4H_2O$
	Zinc sulfate heptahydrate	108883	$ZnSO_4 \cdot 7H_2O$
	Zinc sulfate monohydrate	108882	$ZnSO_4 \cdot H_2O$

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in relation to temperature

Solubility in g/100 g H_2O at °C						Content of the total solution at 20 °C [%]	Density of the total solution at 20 °C [%]
0	20	40	60	80	100		
44.1	53.9	66.6	85.2	–	–	35.0	1.39
0.35	0.7	1.5	3.1	7.0	24.2	0.69	–
–	–	91.2	94.2	97.2	101.2	–	–
83.9	269.8 (15 °C)	–	–	–	–	72.96 (15 °C)	2.07
390.0	440.0	–	620.0	640.0	670.0	–	–
–	–	453.0	488.0	541.0	–	–	–
–	–	211.5	–	–	–	–	–
41.6	53.8	–	–	–	–	35.0	1.47
–	–	–	76.5	66.7	60.5	–	–

Solubility products of slightly Soluble inorganic compounds

	Substance	Formula	Solubility product at given temperature [mol/l]	
A	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°)
B	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°)
C	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°)
	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°)
I	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°)
L	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°)

Solubility products of slightly Soluble inorganic compounds

	Substance	Formula	Solubility product at given temperature [mol/l]	
L	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} 3.20×10^{-8}	(9°) (18°)
	Lead iodate	$Pb(IO_3)_2$	5.30×10^{-14} 1.20×10^{-13} 2.60×10^{-13}	(9.2°) (18°) (25.8°)
	Lead iodide	PbI_2	7.50×10^{-9} 1.40×10^{-9}	(15°) (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°)
M	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°)
M	Mercury(I) sulfide	Hg_2S	1.00×10^{-47}	(18°)
	Mercury(II) sulfide	HgS	3.00×10^{-54}	(18°)
N	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°)
P	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°)
S	Silver arsenate	Ag_3AsO_4	1.00×10^{-19}	(25°)
	Silver bromide	AgBr	4.10×10^{-13} 7.70×10^{-13}	(18°) (25°)
	Silver chloride	AgCl	0.21×10^{-10} 0.37×10^{-10} 1.56×10^{-10} 13.2×10^{-10} 215×10^{-10}	(4.7°) (9.7°) (25°) (50°) (100°)

Solubility products of slightly Soluble inorganic compounds

	Substance	Formula	Solubility product at given temperature [mol/l]	
	Silver chromate	Ag_2CrO_4	1.20×10^{-12} 9.00×10^{-12}	(14.8°) (25°)
	Silver iodide	AgI	0.32×10^{-16} 1.50×10^{-16}	(13°) (25°)
	Silver sulfide	Ag_2S	1.60×10^{-49}	(18°)
	Silver thiocyanate	AgSCN	0.49×10^{-12} 1.16×10^{-12}	(18°) (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} 3.80×10^{-7}	(2.9°) (17.4°)
T	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°)
Z	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 prepartation

The more complicated the matrix, the more important the sample preparation! The better the sample preparation, the simpler the subsequent chromatographic separation!

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* DIN = Deutsches Institut für Normung e.V. (German Institute of Standardization)

Sulfuric acid

H_2SO_4, M = 98.08 g/mol

Density $d\ ^{20°}_{4°}$	H_2SO_4 content	
	weight%	mol/l
1.000	0.2609	0.0266
1.005	0.9855	0.101
1.010	1.731	0.1783
1.015	2.485	0.2595
1.020	3.242	0.3372
1.025	4.000	0.4180
1.030	4.746	0.4983
1.035	5.493	0.5796
1.040	6.237	0.6613
1.045	6.956	0.7411
1.050	7.704	0.8250
1.055	8.415	0.9054
1.060	9.129	0.9865
1.065	9.843	1.066
1.070	10.56	1.152
1.075	11.26	1.235
1.080	11.96	1.317
1.085	12.66	1.401
1.090	13.36	1.484
1.095	14.04	1.567
1.100	14.73	1.652
1.105	15.41	1.735
1.110	16.08	1.820
1.115	16.76	1.905
1.120	17.43	1.990
1.125	18.09	2.075
1.130	18.76	2.161
1.135	19.42	2.247
1.140	20.08	2.334
1.145	20.73	2.420
1.150	21.38	2.507
1.155	22.03	2.594
1.160	22.67	2.681
1.165	23.31	2.768
1.170	23.95	2.857
1.175	24.58	2.945
1.180	25.21	3.033
1.185	25.84	3.122
1.190	26.47	3.211
1.195	27.10	3.302
1.200	27.72	3.302
1.205	28.33	3.481
1.210	28.95	3.572
1.215	29.57	3.663
1.220	30.18	3.754
1.225	30.79	3.846
1.230	31.40	3.938
1.235	32.01	4.031
1.240	32.61	4.123
1.245	33.22	4.216
1.250	33.82	4.310
1.255	34.42	4.404
1.260	35.01	4.498
1.265	35.60	4.592
1.270	36.19	4.686
1.275	36.78	4.781
1.280	37.36	4.876
1.285	37.95	4.972
1.290	38.53	5.068
1.295	39.10	5.163
1.300	39.68	5.259
1.305	40.25	5.356
1.310	40.82	5.452
1.315	41.39	5.549
1.320	41.95	5.646
1.325	42.51	5.743
1.330	43.07	5.840
1.335	43.62	5.938
1.340	44.17	6.035
1.345	44.72	6.132
1.350	45.26	6.229
1.355	45.80	6.327
1.360	46.33	6.424
1.365	46.86	6.522
1.370	47.39	6.620
1.375	47.92	6.718
1.380	48.45	6.817
1.385	48.97	6.915
1.390	49.48	7.012
1.395	49.99	7.110
1.400	50.50	7.208
1.405	51.01	7.307
1.410	51.52	7.406
1.415	52.02	7.505
1.420	52.51	7.603
1.425	53.01	7.702
1.430	53.50	7.801
1.435	54.00	7.901
1.440	54.49	8.000
1.445	54.97	8.099
1.450	55.45	8.198
1.455	55.93	8.297
1.460	56.41	8.397
1.465	56.89	8.497
1.470	57.36	8.598
1.475	57.84	8.699
1.480	58.31	8.799
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
1.490	59.24	9.000
1.495	59.70	9.100
1.500	60.17	9.202
1.505	60.62	9.303
1.510	61.08	9.404
1.515	61.54	9.506
1.520	62.00	9.608
1.525	62.45	9.711
1.530	62.91	9.8136
1.535	63.36	9.916
1.540	63.81	10.02
1.545	64.26	10.12
1.550	64.71	10.23
1.555	65.15	10.33
1.560	65.59	10.43
1.565	66.03	10.54
1.570	66.47	10.64
1.575	66.91	10.74
1.580	67.35	10.85
1.585	67.79	10.96
1.590	68.23	11.06
1.595	68.66	11.16
1.600	69.09	11.27
1.605	69.53	11.38
1.610	69.96	11.48
1.615	70.39	11.59
1.620	70.82	11.70
1.625	71.25	11.80
1.630	71.67	11.91
1.635	72.09	12.02
1.640	72.52	12.13
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

Density $d\ ^{20°}_{4°}$	H_2SO_4 content	
	weight%	mol/l
1.735	80.70	14.28
1.740	81.16	14.40
1.745	81.62	14.52
1.750	82.09	14.65
1.755	82.57	14.78
1.760	83.06	14.90
1.765	83.57	15.04
1.770	84.08	15.17
1.775	84.61	15.31
1.780	85.16	15.46
1.785	85.74	15.61
1.790	86.35	15.76
1.795	86.99	15.92
1.800	87.69	16.09
1.805	88.43	16.27
1.810	89.23	16.47
1.815	90.12	16.68
1.820	91.11	16.91
1.821	91.33	16.96
1.822	91.56	17.01
1.823	91.78	17.06
1.824	92.00	17.11
1.825	92.25	17.17
1.826	92.51	17.22
1.827	92.77	17.28
1.828	93.03	17.34
1.829	93.33	17.40
1.830	93.64	17.47
1.831	93.94	17.54
1.832	94.32	17.62
1.833	94.72	17.70

Phosphoric acid

H_3PO_4, M = 97.99 g/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

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Nitric acid

HNO_3, M = 63.02 g/mol

Density $d_4^{20°}$	HNO_3 content	
	weight%	mol/l
1.000	0.3333	0.05231
1.005	1.255	0.2001
1.010	2.164	0.3468
1.015	3.073	0.4950
1.020	3.982	0.6445
1.025	4.883	0.7943
1.030	5.784	0.9454
1.035	6.661	1.094
1.040	7.530	1.243
1.045	8.398	1.393
1.050	9.259	1.543
1.055	10.12	1.694
1.060	10.97	1.845
1.065	11.81	1.997
1.070	12.65	2.148
1.075	13.48	2.301
1.080	14.31	2.453
1.085	15.13	2.605
1.090	15.95	2.759
1.095	16.76	2.913
1.100	17.58	3.068
1.105	18.39	3.224
1.110	19.19	3.381
1.115	20.00	3.539
1.120	20.79	3.696
1.125	21.59	3.854
1.130	22.38	4.012
1.135	23.16	4.171
1.140	23.94	4.330
1.145	24.71	4.489
1.150	25.48	4.649
1.155	26.24	4.810
1.160	27.00	4.970
1.165	27.76	5.132
1.170	28.51	5.293
1.175	29.25	5.455
1.180	30.00	5.618
1.185	30.74	5.780
1.190	31.47	5.943
1.195	32.21	6.107
1.200	32.94	6.273
1.205	33.68	6.440
1.210	34.41	6.607
1.215	35.16	6.778
1.220	35.93	6.956
1.225	36.70	7.135
1.230	37.48	7.315
1.235	38.25	7.497
1.240	39.02	7.679
1.245	39.80	7.863
1.250	40.58	8.049
1.255	41.36	8.237

Density $d_4^{20°}$	HNO_3 content	
	weight%	mol/l
1.260	42.14	8.426
1.265	42.92	8.616
1.270	43.70	8.808
1.275	44.48	9.001
1.280	45.27	9.195
1.285	46.06	9.394
1.290	46.85	9.590
1.295	47.63	9.789
1.300	48.42	9.990
1.305	49.21	10.19
1.310	50.00	10.39
1.315	50.85	10.61
1.320	51.71	10.83
1.325	52.56	11.05
1.330	53.41	11.27
1.335	54.27	11.49
1.340	55.13	11.72
1.345	56.04	11.96
1.350	56.95	12.20
1.355	57.87	12.44
1.360	58.78	12.68
1.365	59.69	12.93
1.370	60.67	13.19
1.375	61.69	13.46
1.380	62.70	13.73
1.385	63.72	14.01
1.390	64.74	14.29
1.395	65.84	14.57
1.400	66.97	14.88
1.405	68.10	15.18
1.410	69.23	15.49
1.415	70.39	15.81
1.420	71.63	16.14
1.425	72.86	16.47
1.430	74.09	16.81
1.435	75.35	17.16
1.440	76.71	17.53
1.445	78.07	17.90
1.450	79.43	18.28
1.455	80.88	18.68
1.460	82.39	19.09
1.465	83.91	19.51
1.470	85.50	19.95
1.475	87.29	20.43
1.480	89.07	20.92
1.485	91.13	21.48
1.490	93.49	22.11
1.495	95.46	22.65
1.500	96.73	23.02
1.501	96.98	23.10
1.502	97.23	23.18
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 $d\ ^{20°}_{4°}$	H_2SO_4 content	
	weight%	mol/l
1.000	0.159	0.0398
1.005	0.602	0.151
1.010	1.0455	0.264
1.015	1.49	0.378
1.020	1.94	0.494
1.025	2.39	0.611
1.030	2.84	0.731
1.035	3.29	0.851
1.040	3.745	0.971
1.045	4.20	1.097
1.050	4.655	1.222
1.055	5.11	1.347
1.060	5.56	1.474
1.065	6.02	1.602
1.070	6.47	1.731
1.075	6.93	1.862
1.080	7.38	1.992
1.085	7.83	2.123
1.090	8.28	2.257
1.095	8.74	2.391
1.100	9.19	2.527
1.105	9.64	2.664
1.110	10.10	2.802
1.115	10.55	2.942
1.120	11.01	3.082
1.125	11.46	3.224
1.130	11.92	3.367
1.135	12.37	3.510
1.140	12.83	3.655
1.145	13.28	3.801
1.150	13.73	3.947
1.155	14.18	4.095
1.160	14.64	4.244
1.165	15.09	4.395
1.170	15.54	4.545
1.175	15.99	4.697
1.180	16.44	4.850
1.185	16.89	5.004
1.190	17.34	5.160
1.195	17.80	5.317
1.200	18.25	5.476
1.205	18.71	5.636

Acids in Safebreak bottles

Acids in glass bottles have hazard potential: glass can break!

Sodium hydroxide solution

NaOH, M = 40.01 g/mol

Density $d_4^{20°}$	NaOH content	
	weight%	mol/l
1.210	19.16	5.796
1.215	19.62	5.958
1.220	20.07	6.122
1.225	20.53	6.286
1.230	20.98	6.451
1.235	21.44	6.619
1.240	21.90	6.788
1.245	22.36	6.958
1.250	22.82	7.129
1.255	23.275	7.302
1.260	23.73	7.475
1.265	24.19	7.650
1.270	24.645	7.824
1.275	25.10	8.000
1.280	25.56	8.178
1.285	26.02	8.357
1.290	26.48	8.539
1.295	26.94	8.722
1.300	27.41	8.906
1.305	27.87	9.092
1.310	28.33	9.278
1.315	28.80	9.466
1.320	29.26	9.656
1.325	29.73	9.875
1.330	30.20	10.04
1.335	30.67	10.23
1.340	31.14	10.43
1.345	31.62	10.63
1.350	32.10	10.83
1.355	32.58	11.03
1.360	33.06	11.24
1.365	33.54	11.45

Density $d_4^{20°}$	NaOH content	
	weight%	mol/l
1.370	34.03	11.65
1.375	34.52	11.86
1.380	35.01	12.08
1.385	35.505	12.29
1.390	36.00	12.51
1.395	36.495	12.73
1.400	36.99	12.95
1.405	37.49	13.17
1.410	37.99	13.39
1.415	38.49	13.61
1.420	38.99	13.84
1.425	39.495	14.07
1.430	40.00	14.30
1.435	40.515	14.53
1.440	41.03	14.77
1.445	41.55	15.01
1.450	42.07	15.25
1.455	42.59	15.49
1.460	43.12	15.74
1.465	43.64	15.98
1.470	44.17	16.23
1.475	44.695	16.48
1.480	45.22	16.73
1.485	45.75	16.98
1.490	46.27	17.23
1.495	46.80	17.49
1.500	47.33	17.75
1.505	47.85	18.00
1.510	48.38	18.26
1.515	48.905	18.52
1.520	49.44	18.78
1.525	49.97	19.05
1.530	50.50	19.31

Potassium hydroxide solution

KOH, M = 56.11 g/mol

Density $d_{4°}^{20°}$	KOH content	
	weight%	mol/l
1.000	0.197	0.0351
1.005	0.743	0.133
1.010	1.295	0.233
1.015	1.84	0.333
1.020	2.38	0.4355
1.025	2.93	0.536
1.030	3.48	0.6395
1.035	4.03	0.774
1.040	4.58	0.848
1.045	5.12	0.954
1.050	5.66	1.06
1.055	6.20	1.17
1.060	6.74	1.27
1.065	7.28	1.38
1.070	7.82	1.49
1.075	8.36	1.60
1.080	8.89	1.71
1.085	9.43	1.82
1.090	9.96	1.94
1.095	10.49	2.05
1.100	11.03	2.16
1.105	11.56	2.28
1.110	12.08	2.39
1.115	12.61	2.51
1.120	13.14	2.62
1.125	13.66	2.74
1.130	14.19	2.86
1.135	14.705	2.975
1.140	15.22	3.09
1.145	15.74	3.21
1.150	16.26	3.33
1.155	16.78	3.45

Density $d_{4°}^{20°}$	KOH content	
	weight%	mol/l
1.160	17.29	3.58
1.165	17.81	3.70
1.170	18.32	3.82
1.175	18.84	3.945
1.180	19.35	4.07
1.185	19.86	4.195
1.190	20.37	4.32
1.195	20.88	4.45
1.200	21.38	4.57
1.205	21.88	4.70
1.210	22.38	4.83
1.215	22.88	4.955
1.220	23.38	5.08
1.225	23.87	5.21
1.230	24.37	5.34
1.235	24.86	5.47
1.240	25.36	5.60
1.245	25.85	5.74
1.250	26.34	5.87
1.255	26.83	6.00
1.260	27.32	6.135
1.265	27.80	6.27
1.270	28.29	6.40
1.275	28.77	6.54
1.280	29.25	6.67
1.285	29.73	6.81
1.290	30.21	6.95
1.295	30.68	7.08
1.300	31.15	7.22
1.305	31.62	7.36
1.310	32.09	7.49
1.315	32.56	7.63

Potassium hydroxide solution

KOH, M = 56.11 g/mol

Density $d_{4°}^{20°}$	KOH content	
	weight%	mol/l
1.000	0.197	0.0351
1.005	0.743	0.133
1.010	1.295	0.233
1.015	1.84	0.333
1.020	2.38	0.4355
1.025	2.93	0.536
1.030	3.48	0.6395
1.035	4.03	0.774
1.040	4.58	0.848
1.045	5.12	0.954
1.050	5.66	1.06
1.055	6.20	1.17
1.060	6.74	1.27
1.065	7.28	1.38
1.070	7.82	1.49
1.075	8.36	1.60
1.080	8.89	1.71
1.085	9.43	1.82
1.090	9.96	1.94
1.095	10.49	2.05
1.100	11.03	2.16
1.105	11.56	2.28
1.110	12.08	2.39
1.115	12.61	2.51
1.120	13.14	2.62
1.125	13.66	2.74
1.130	14.19	2.86

Density $d_{4°}^{20°}$	KOH content	
	weight%	mol/l
1.135	14.705	2.975
1.140	15.22	3.09
1.145	15.74	3.21
1.150	16.26	3.33
1.155	16.78	3.45
1.160	17.29	3.58
1.165	17.81	3.70
1.170	18.32	3.82
1.175	18.84	3.945
1.180	19.35	4.07
1.185	19.86	4.195
1.190	20.37	4.32
1.195	20.88	4.45
1.200	21.38	4.57
1.205	21.88	4.70
1.210	22.38	4.83
1.215	22.88	4.955
1.220	23.38	5.08
1.225	23.87	5.21
1.230	24.37	5.34
1.235	24.86	5.47
1.240	25.36	5.60
1.245	25.85	5.74
1.250	26.34	5.87
1.255	26.83	6.00
1.260	27.32	6.135
1.265	27.80	6.27

Potassium hydroxide solution

KOH, M = 56.11 g/mol

Density $d_{4°}^{20°}$	KOH content	
	weight%	mol/l
1.270	28.29	6.40
1.275	28.77	6.54
1.280	29.25	6.67
1.285	29.73	6.81
1.290	30.21	6.95
1.295	30.68	7.08
1.300	31.15	7.22
1.305	31.62	7.36
1.310	32.09	7.49
1.315	32.56	7.63
1.320	33.03	7.77
1.325	33.50	7.91
1.330	33.97	8.05
1.335	34.43	8.19
1.340	34.90	8.335
1.345	35.36	8.48
1.350	35.82	8.62
1.355	36.28	8.76
1.360	36.735	8.905
1.365	37.19	9.05
1.370	37.65	9.19
1.375	38.105	9.34
1.380	38.56	9.48
1.385	39.01	9.63
1.390	39.46	9.78
1.395	39.92	9.93
1.400	40.37	10.07

Density $d_{4°}^{20°}$	KOH content	
	weight%	mol/l
1.405	40.82	10.22
1.410	41.26	10.37
1.415	41.71	10.52
1.420	42.155	10.67
1.425	42.60	10.82
1.430	43.04	10.97
1.435	43.48	11.12
1.440	43.92	11.28
1.445	44.36	11.42
1.450	44.79	11.58
1.455	45.23	11.73
1.460	45.66	11.88
1.465	46.095	12.04
1.470	46.53	12.19
1.475	46.96	12.35
1.480	47.39	12.50
1.485	47.82	12.66
1.490	48.25	12.82
1.495	48.675	12.97
1.500	49.10	13.13
1.505	49.53	13.29
1.510	49.95	13.45
1.515	50.38	13.60
1.520	50.80	13.76
1.525	51.22	13.92
1.530	51.64	14.08

Ammonia

NH_3, M = 17.03 g/mol

Density $d_4^{20°}$	NH_3 content	
	weight%	mol/l
0.998	0.0465	0.0273
0.996	0.512	0.299
0.994	0.977	0.570
0.992	1.43	0.834
0.990	1.89	1.10
0.988	2.35	1.365
0.986	2.82	1.635
0.984	3.30	1.91
0.982	3.78	2.18
0.980	4.27	2.46
0.978	4.76	2.73
0.976	5.25	3.01
0.974	5.75	3.29
0.972	6.25	3.57
0.970	6.75	3.84
0.968	7.26	4.12
0.966	7.77	4.41
0.964	8.29	4.69
0.962	8.82	4.98
0.960	9.34	5.27
0.958	9.87	5.55
0.956	10.405	5.84
0.954	10.95	6.13
0.952	11.49	6.42
0.950	12.03	6.71
0.948	12.58	7.00
0.946	13.14	7.29
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

Density $d_4^{20°}$	NH_3 content	
	weight%	mol/l
0.932	17.24	9.44
0.930	17.85	9.75
0.928	18.45	10.06
0.926	19.06	10.37
0.924	19.67	10.67
0.922	20.27	10.97
0.920	20.88	11.28
0.918	21.50	11.59
0.916	22.125	11.90
0.914	22.75	12.21
0.912	23.39	12.52
0.910	24.03	12.84
0.908	24.68	13.16
0.906	25.33	13.48
0.904	26.00	13.80
0.902	26.67	14.12
0.900	27.33	14.44
0.898	28.00	14.76
0.896	28.67	15.08
0.894	29.33	15.40
0.892	30.00	15.71
0.890	30.685	16.04
0.888	31.37	16.36
0.886	32.09	16.69
0.884	32.84	17.05
0.882	33.595	17.40
0.880	34.35	17.75

Commercially available concentrations of some acids and alkalis

Name	weight%	Density $d\ ^{20°}_{4°}$	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, concentration (1.16)	32	1.16	10
Hydrochloric acid, concentration (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, concentration	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, concentration (1.71)	85	1.71	15
Phosphoric acid, concentration (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, concentration	95 – 97	1.84	18
Sulfuric acid, dilute	25	1.18	3

* rounded off

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

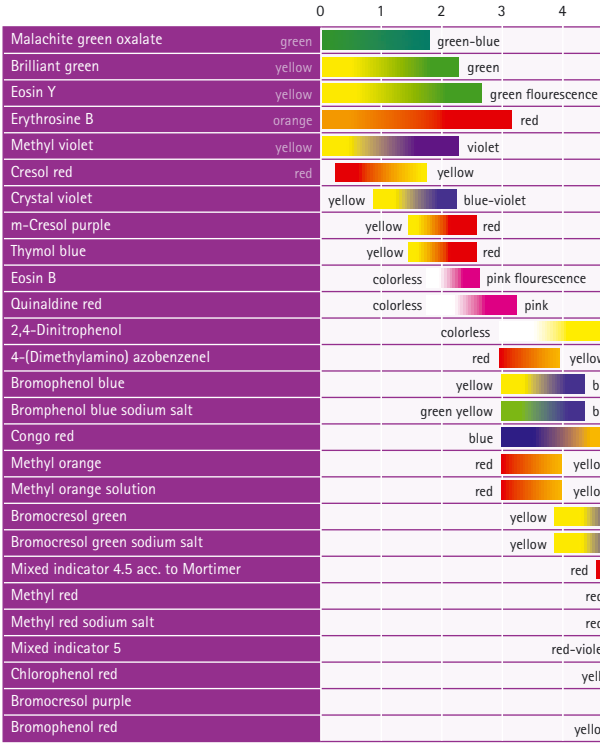
Example

Sodium hydroxide solution 40 % with a density of 1.430 g/cm³

$145 - \frac{145}{\text{density}} = 43.60\ °Bé$

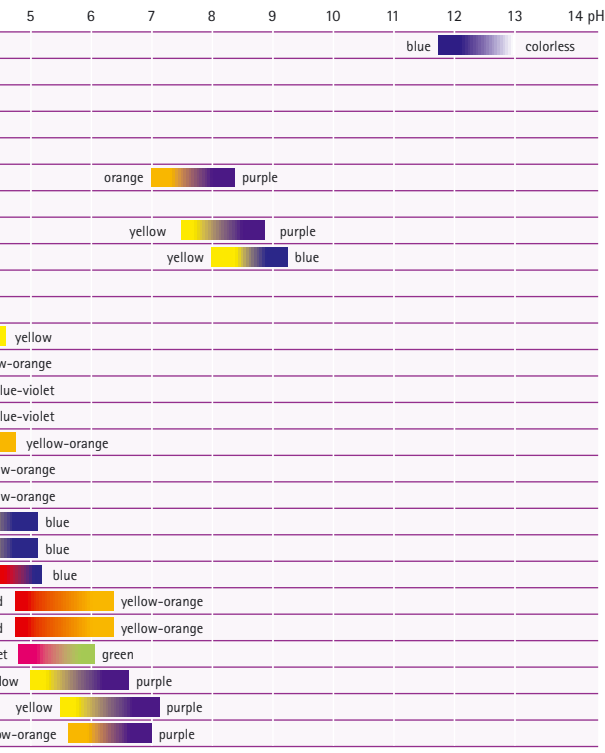
Indicators and buffers

pH-indicators



The pH ranges and color shades shown are approximations

For more information please visit www.merck-chemicals.com/labtools
than choose "pH-Indicator Selector"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yellow-orange
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w-orange
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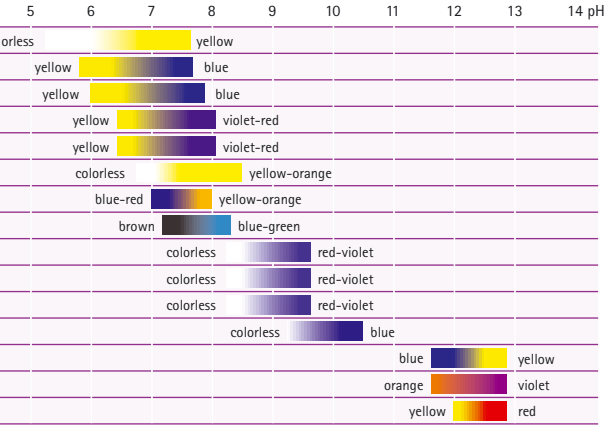
blue
blue
yellow-orange
yellow-orange
green
purple
yellow
purple
w-orange
purple

pH-indicators

	0	1	2	3	4	
4-Nitrophenol						col
Bromothymol blue sodium salt						
Bromothymol blue						
Phenol red						
Phenol red sodium salt						
3-Nitrophenol						
Neutral red						
1-Naphtholphthalein						
Phenolphthalein						
Phenolphthalein solution (1 % in ethanol)						
Phenolphthalein solution (0.375 % in methanol)						
Thymolphthalein						
Indigo carmine						
Epsilon blue						
Titan yellow						

The pH ranges and color shades shown are approximations

The broad pH test range offers you an optimal solution for each application area. You can easily and quickly measure the pH without using instruments.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14 pH
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blue
yellow
blue
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violet-red
yellow
violet-red
colorless
yellow-orange
blue-red
yellow-orange
brown
blue-green
colorless
red-violet
colorless
red-violet
colorless
red-violet
colorless
blue
blue
yellow
orange
violet
yellow
red

Buffer solutions

Prepare stock and buffer solutions with distilled, boiled, CO_2-free water.

Buffer-solution No.	Stock solutions and their content of buffer substance		Composition of buffer solution
	A	B	
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	50 ml A + x ml B, make up to 100 ml*
5	As No. 2	NaOH 0.1 mol/l	x parts A + (100-x) parts B
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	x parts A + (100-x) parts B
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

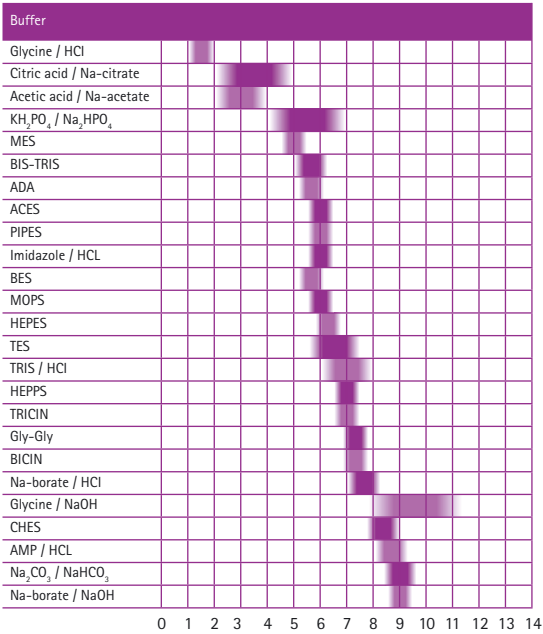
* fill up with dissolution

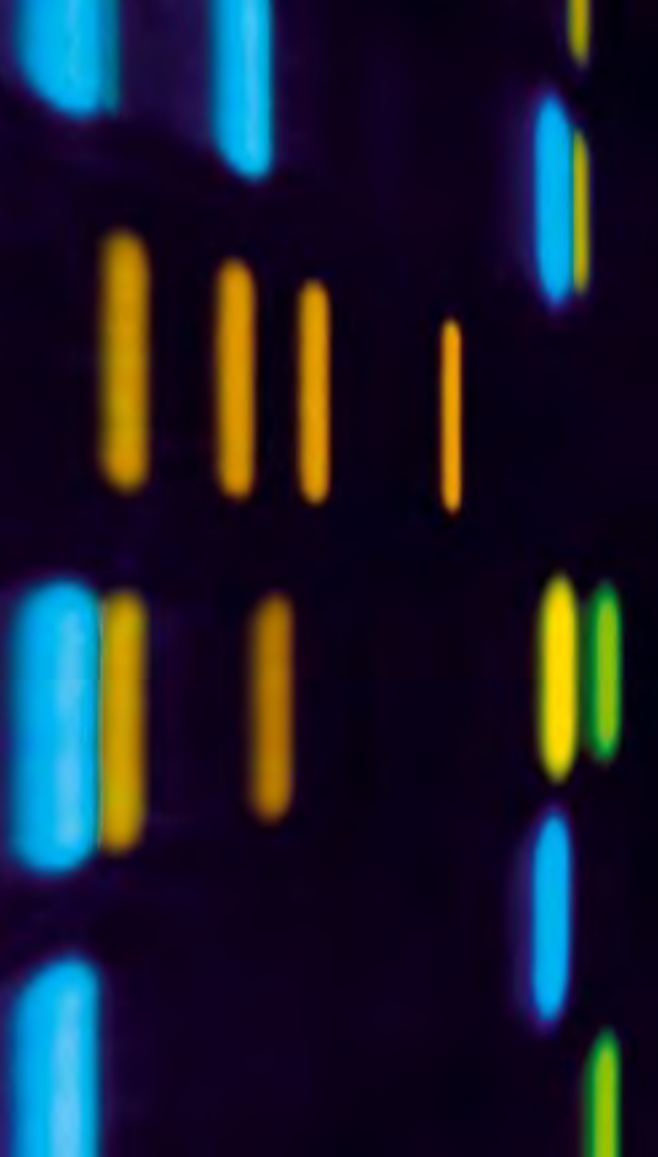
CertiPUR®-Buffer Sachets for calibration of pH instruments!

pKa values of selected biological buffers

Buffer	pKa [4 °C]	pKa [20 °C]	pKa [25 °C]	pKa [37 °C]	△pKa/°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	7.32	– 0.014
HEPPS	8.18	8.00	7.95	7.82	– 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





Analytical chromatography

Thin-layer chromatography

Thin-layer chromatography is a simple, fast and highly versatile separation tool for both qualitative and quantitative analysis. The field of application covers virtually all classes of substances including pesticides, steroids, alkaloids, lipids, nucleotides, glycosides, carbohydrates, fatty acids and many others.

- Cheap separation method without the need for sophisticated instruments
- No cumbersome sample preparation step needed because plates are disposable
- Sample components are stored on the plate allowing to repeat the analysis several times
- Multiple samples (up to 72) can be run simultaneously under identical conditions
- Easy 2 dimensional separation by using two distinct mobile phases in different directions

Thin-layer chromatography can be a manual method as in classical TLC, or automated as in instrumented high-performance thin-layer chromatography (HPTLC). Furthermore, it can be easily extended to preparative scale for PLC.

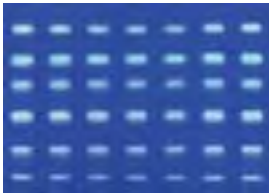
Unmodified silica gel covers more than 80 % of thin-layer chromatography applications for both adsorption- and partition thin-layer chromatography. It allows separating a large range of different substances such as aflatoxins, alkaloids, anabolics, benzodiazepins, carbohydrates, fatty acids, glycosides, lipids, mycotoxins, nucleotides, peptides, pesticides, steroids, sulfonamids, surfactants, tetracyclines and many others making it suitable for:

- In-process control in drugs
- Purity checks of synthesis steps
- Identity testing of pharmaceutical compounds

HPTLC Premium Purity plate is designed for high performance, completely contamination free separations especially in demanding pharmacopoeia applications.

- Highly pure, exhibiting minimal background even with middle-polar solvent systems
- Identical separation performance as the related HPTLC plate product
- Especially suited for pharmacopoeia applications

Aluminium and plastic backed plates can be cut to smaller size to reduce the cost of analysis.



Comparison of the separation of dansyl amino acids on a
(A) *classical TLC silica gel 60 plate or*
(B) *HPTLC silica gel 60 plate under identical conditions. The comparison clearly demonstrates that the HPTLC plate delivers sharper zones with shorter migration distances and hence running times. In addition the HPTLC plate allows the separation of twice the number of samples simultaneously.*

Compounds:
1. N-alpha-dansyl-L-arginine
2. alpha-dansyl-L-arginine
3. Dansyl-L-cysteic acid
4. N-Dansyl-glycine
5. Dansyl-glycine
6. N-N-Didansyl-L-tyrosine

Sample volume:	*TLC 4 µl; HPTLC 0,3 µl*
Mobil phase:	*Ethyl acetat / methanol / propionic acid (22/10/3)*
Migration distance:	*TLC 10 cm; HPTLC 5 cm*
Analysis time:	*TLC 42 min; HPTLC 13 min 45 sec*
Detection:	*UV 366*

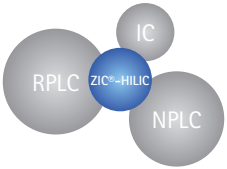
Analytical HPLC

Analytical HPLC has taken on a position of central importance in research and development, in pharmaceutical quality control and in environmental analysis. Merck is among the major suppliers of HPLC products worldwide.
Our extensive portfolio comprises products for analytical and preparative HPLC. With our series of very widely used HPLC sorbents, which includes LiChrosorb®, LiChrospher®, Superspher®, Purospher® and SeQuant™ ZIC®-HILIC, we offer you the most suitable products for your application. With Chromolith® – an HPLC column based on monolithic technology – we have established and maintained technology leadership in chromatography to ideally fulfill your requirements.

- **LiChrospher®** is a reliable and versatile traditionally produced spherical silica carrier with a particle size of 5 µm or 10 µm, providing well balanced pressure / separation performance ratio. A broad range of modifications on LiChrospher® are very widely used by HPLC-users all over the world for a broad range of applications. LiChrospher® sorbents are available as reversed phase derivatives (RP-8, RP-18 endcapped, RP-18, RP-18 endcapped and RP-select B), medium polar (NH_2, CN, DIOL) and polar derivatives (Si 60). Furthermore LiChrospher® PAH is highly efficient and selective for the separation of PAH; LiChrospher® WP is very well suited for the separation of peptides and low molecular weight proteins.

- **Purospher® HPLC** columns are based upon a high-purity silica for excellent separations with very good peak symmetry. The base material for Purospher® high-purity HPLC columns consists of tetra-alkoxysilane.
  Due to the absence of heavy metals in the silica matrix and in combination with a complete coverage of the silica surface, this stationary phase enables tailing-free chromatography of acidic, basic and chelating compounds. This is of particular advantage for method development.
  Thanks to its outstanding performance and stability, Purospher® STAR RP-18 endcapped is the most versatile column in the Purospher® range.
  Robust methods can be developed across the entire pH spectrum from 1.5 to 10.5 enabling the use of the complete range of mobile phases and temperatures. In addition Purospher® STAR RP-18 endcapped, 2 µm and 3 µm UHPLC columns speed separation up to 10 times and save up to 84.5 % solvent.

- **SeQuant™ ZIC®-HILIC HPLC** columns provides excellent selectivity for separation of strongly polar and hydrophilic compounds, which often have little or no retention on reversed phase columns. Merck´s unique **ZIC®-HILIC technology** is based on a stationary phase with a covalently bonded, highly polar zwitterionic functional group that provides higher stability and more robust HILIC separations than conventional silica or amino phases.



Schematic illustration demonstrating how **ZIC®-HILIC** *complements other areas of chromatography and extends the separation capabilities.*

- **Chromolith® HPLC** columns provide excellent separations in a fraction of the time that a standard particulate column will take – typically four times faster, because they are made from highly porous monolithic rods of silica with a bimodal pore structure. The column is no longer packed with small particles but instead consists of a single piece of high-purity silica gel. Longer lifetime and lower matrix sensitivity with biological samples are additional advantages of Chromolith® columns. Multiple Chromolith® columns coupled together provide separation efficiencies of 100,000 plates / column at normal pressure.

Specifications of column sorbents

Polar stationary phases (normal phase chromatography)

(shipping eluent: n-Heptane / Dioxane (99/1))

Designation	Sorbent characteristics	Particle size
LiChrosorb® Si 60	irregular particles of silica	5, 7, 10 µm
LiChrosorb® Si 100	irregular particles of silica	5, 7, 10 µm
LiChrospher® Si 60	spherical particles of silica	5, 10 µm
LiChrospher® Si 100	spherical particles of silica	5, 10 µm
LiChrospher® Si 300	spherical particles of silica	10 µm
LiChrospher® Si 1000	spherical particles of silica	10 µm
LiChrospher® Si 4000	spherical particles of silica	10 µm
Superspher® Si 60	spherical particles of silica	4 µm
Purospher® STAR Si	spherical particles of high purity silica	5 µm
Chromolith® Si	Monolithic high purity silica	monolithic

Specifications of column sorbents

Medium solar stationary phases

(shipping eluent: n-Heptane / Dioxane (99/1))

Designation	Sorbent characteristics	Particle size
LiChrosorb® CN	irregular particles of silica with γ-Cyanopropyl function	5, 10 µm
LiChrosorb® NH_2	irregular particles of silica with γ-Aminopropyl function	5, 10 µm
LiChrosorb® DIOL	spherical particles of silica with DIOL function on carbonchains	5, 10 µm
LiChrospher® CN	spherical particles of silica with γ-Cyanopropyl function	5, 10 µm
LiChrospher® NH_2	spherical particles of silica with γ-Aminopropyl function	5, 10 µm
LiChrospher® DIOL	spherical particles of silica with DIOL function on carbonchains	5, 10 µm
Purospher® STAR NH_2	spherical particles of high purity silica with γ-Aminopropyl function	5 µm

	Pore size	Pore volume	Spec. surface area	Efficiency
	60 Å	0.75 ml/g	500 m^2/g	55 000 N/m 15 000 N/m
	100 Å	1.0 ml/g	300 m^2/g	
	60 Å	0.85 ml/g	700 m^2/g	55 000 N/m 20 000 N/m
	100 Å	1.25 ml/g	400 m^2/g	55 000 N/m 20 000 N/m
	300 Å	0.78 ml/g	60 m^2/g	20 000 N/m
	1000 Å	0.78 ml/g	30 m^2/g	15 000 N/m
	4000 Å	0.78 ml/g	10 m^2/g	15 000 N/m
	60 Å	0.85 ml/g	700 m^2/g	100 000 N/m
	120	1.1	330	50 000 N/m
	130	1 ml/g	300	

	Pore size	Pore volume	Spec. surface	% C	Surface coverage	Efficiency
	100 Å	1.0 ml/g	300 m^2/g	6.1 %	3.82 µmol/m^2	40 000 N/m 15 000 N/m
	100 Å	1.0 ml/g	300 m^2/g	3.5 %	3.54 µmol/m^2	
	100 Å	1.0 ml/g	300 m^2/g	7.1 %	3.91 µmol/m^2	25 000 N/m 10 000 N/m
	100 Å	1.25 ml/g	350 m^2/g	6.6 %	3.52 µmol/m^2	40 000 N/m 15 000 N/m
	100 Å	1.25 ml/g	350 m^2/g	4.6 %	41 µmol/m^2	40 000 N/m 15 000 N/m
	100 Å	1.25 ml/g	350 m^2/g	8.0 %	3.87 µmol/m^2	25 000 N/m 20 000 N/m
	120	1.1	330	3.5	3	50 000 N/m

Specifications of column sorbents

Non-polar stationary phases (reversed phase chromatography)

(shipping eluent: acetronitrile / water)

Designation	Sorbent characteristics	Particle size
LiChrosorb® RP-8	irregular particles of silica with octyl derivative	5, 7, 10 µm
LiChrosorb® RP-select B	irregular particles of silica with octyl derivative	5, 7, 10 µm
LiChrosorb® RP-18	irregular particles of silica with octyl derivative	5, 7, 10 µm
LiChrospher® RP-8	spherical particles of silica with octyl derivative	5, 10 µm
LiChrospher® RP-8 endcapped	spherical particles of silica with octyl derivative endcapped	5, 10 µm
LiChrospher® RP-select B	spherical particles of silica with octyl derivative	5, 10 µm
LiChrospher® RP-18	spherical particles of silica with octadecyl derivative	5, 10 µm
LiChrospher® RP-18 endcapped	spherical particles of silica with octadecyl derivative endcapped	5, 10 µm
LiChrospher® WP 300 RP-18	spherical particles of silica with octadecyl derivative	5, 12, 15 µm
LiChrospher® PAH	spherical particles of silica with octadecyl derivative	5 µm
Superspher® RP-8	spherical particles of silica with octyl derivative	4 µm
Superspher® RP-8 endcapped	spherical particles of silica with octyl derivative endcapped	4 µm
Superspher® RP-select B	spherical particles of silica with octyl derivative	4 µm
Superspher® RP-18	spherical particles of silica with octadecyl derivative	4 µm
Superspher® RP-18 endcapped	spherical particles of silica with octadecyl derivative	4 µm
Purospher® RP-18	spherical particles of high purity silica with octadecyl derivative polar endcapped	5 µm
Purospher® RP-18 endcapped	spherical particles of high purity silica with octadecyl derivative	5 µm
Purospher® STAR RP-8 endcapped	spherical particles of high purity silica with octyl derivative	3, 5 µm
Purospher® STAR RP-18 endcapped	spherical particles of high purity silica with octadecyl derivative	2, 3, 5 µm
Purospher® HC	spherical particles of high purity silica with octadecyl derivative	5 µm
Chromolith® RP-8 endcapped	Monolithic high purity silica with octyl derivative	monolithic
Chromolith® RP-18 endcapped	Monolithic high purity silica with octadecyl derivative	monolithic

	Pore size	Pore volume	Spec. surface	% C	Surface coverage	Efficiency
	100 Å	1.0 ml/g	300 m^2/g	9.5 %	3.4 µmol/m^2	55 000 N/m 20 000 N/m
	60 Å	0.75 ml/g	300 m^2/g	11.4 %	4.21 µmol/m^2	55 000 N/m 20 000 N/m
	100 Å	1.0 ml/g	300 m^2/g	16.2 %	3.0 µmol/m^2	55 000 N/m 20 000 N/m
	100 Å	1.25 ml/g	350 m^2/g	12.5 %	4.04 µmol/m^2	55 000 N/m 20 000 N/m
	100 Å	1.25 ml/g	350 m^2/g	13.0 %	4.44 µmol/m^2	55 000 N/m 20 000 N/m
	60 Å	0.9 ml/g	360 m^2/g	11.5 %	3.55 µmol/m^2	55 000 N/m 20 000 N/m
	100 Å	1.25 ml/g	350 m^2/g	21.0 %	3.61 µmol/m^2	55 000 N/m 20 000 N/m
	100 Å	1.25 ml/g	350 m^2/g	21.6 %	4.09 µmol/m^2	55 000 N/m 20 000 N/m
	300 Å	1.0	80 m^2/g	n.a.	n.a.	n.a.
	150 Å	n.a.	200 m^2/g	20 %	4.04 µmol/m^2	80 000 N/m
	60 Å	1.25 ml/g	350 m^2/g	12.5 %	4.44 µmol/m^2	100 000 N/m
	60 Å	1.25 ml/g	350 m^2/g	13.0 %	3.55 µmol/m^2	100 000 N/m
	60 Å	0.9 ml/g	360 m^2/g	11.5 %	3.61 µmol/m^2	100 000 N/m
	100 Å	1.25 ml/g	350 m^2/g	21.0 %	4.09 µmol/m^2	100 000 N/m
	100 Å	1.25 ml/g	350 m^2/g	21.6 %		100 000 N/m
	90 Å	1.05 ml/g	480 m^2/g	17.0 %		80 000 N/m
	90 Å	1.05 ml/g	480 m^2/g	18.0 %		80 000 N/m
	120 Å	1.1 ml/g	330 m^2/g	11.2 %		130 000 N/m 80 000 N/m
	120 Å	1.1 ml/g	330 m^2/g	17.0 %	3 µmol/m^2	180 000 N/m 130 000 N/m 80 000 N/m
	90 Å	1.05 ml/g	470 m^2/g	18.0 %		
	130	1	300	11.0 %		
	130	1	300	18.0 %		

LC Troubleshooting

Problem	Possible cause
High pressure	Precolumn blocked
	Column head blocked
	Capillary blocked
No peaks; changing peakhight	No flow; leak
	Sample injection is not reproducible
Noise or drift problems	Column is not in equilibrium
	Impurities elute slowly from the column
	Enrichment of impurities
	Differentces in temperature (column or detector)
	Air bubbles
	Detector lamp
	Electrical interferences
Ghost peaks	Peaks from previous injection
	Unknown sample compunds
	Column contamination
	Solvent impurities
	Mixing problems of mobile phase
	Oxidation of TFA (peptinde mapping)
Peaks with shoulders; Fronting	Precolumn defective or soiled
	Cavity at column head (dead-volume) or channels in column packing
	Sample dissolved in wrong solvents
	Interfering compounds; Impurities
	Column overload
	Extra column effects
Peaks are broad	Precolumn or column defective or soiled
	Column overload; injection volume too large
	Sample dissolved in wrong solvent
	Too weak buffer
	Extra column effects

	Solution
	Change precolumn
	Change filter of column head; flush column; change column
	Change capillary
	Checkpump; check frit; check mobil phase composition; fix leak
	Check sample injection system
	Flush column
	Flush colum with strong eluent
	Flush column; improve sample cleanup; use HPLC-grade solvents
	Use column thermostat
	Degas mobile phase; use back-pressure regulator
	Replace UV lamp (expected life time: 1,000 h)
	Use voltage stabilizer; check for local interference sources
	Use longer run-time; flush column with strong solvent after each run; improve sample cleanup; use gradient elution
	Improve sample cleanup
	Flush column with strong solvent after each run; improve sample cleanup
	Use HPLC-grade solvents
	Dissolve sample in mobil phase
	Prepare fresh daily; use antioxidant
	Change precolumn
	Change column
	Dissolve sample in mobil phase or (if not possible) inject very small sample volume (1 µl)
	Improve sample cleanup; check column with test mixture; use HPLC-grade solvents
	Dilute sample
	Check capillary connections
	Change precolumn or column
	Reduce sample volume; dilute sample
	Dissolve sample in mobile phase
	Use higher concentration or different buffer
	Check capillary connections

LC Troubleshooting

Problem	Possible cause
Peaks are broad	Leak between column and detector; large detector cell
	Too low column temperature; high mobile phase viscosity
	Too low column temperature; high mobile phase viscosity
	Too long capillary connections
	Poor column efficiency
Peak tailing	Column overload
	Interfering peaks; Impurities
	Silanol interactions
	Blocked column frit
	Extra column effects; dead-volume
	Column void or channeling
Peak doubling or splitting	Sample volume too large; column overload
	Sample dissolved in wrong solvent
	Column void or channeling
	Blocked column frit
	Unswept injector flowpath
Increasing retention times	Flow rate is decreasing
	Active sites on silica packing
	Loss of bonded stationary phase
	Mobile phase composition changing
	Temperature decreasing
Decreasing retention times	Flow rate is increasing
	Column overload
	Loss of bonded stationary phase
	Mobile phase composition changing
	Temperature increasing
	Column ageing

	Solution
	Fix leak; use smaller cell
	Increase column temperature
	Increase column temperature
	Use shorter capillaries with smaller i.D.; check for dead volume
	Use column with smaller particles
	Decrease sample size; increase column diameter; use higher capacity stationary phase
	Improve sample cleanup; adjust mobile phase; check column with test mixture; use HPLC-grade solvents
	Use modifier (triethylamine); increase buffer or salt concentration (ion-pair-chromatography); lower mobil phase pH; use base deactivated column
	Replace frit; add in-line filter; filter samples
	Check capillary connections
	Replace column; use less aggressive conditions
	Reduce sample volume; dilute sample; inject sample prepared in mobil phase
	Dissolve sample in mobile phase or (if not possible) inject very small sample volume (1 µl)
	Replace column; use less aggressive conditions
	Replace frit; add in-line filter; filter samples
	Replace injecto rotor
	Fix leaks; replace pump seals; remove bubbles; check for cavitation
	Use mobile phase modifier; add triethylamine; use base-deactivated column
	Keep mobile phase pH between 2 and 7.5
	Check pump; check frit; avoid evaporation or degradation of mobile phase
	Use column thermostat
	Check pump; check flow
	Decrease sample size
	Keep mobile phase pH between 2 and 7.5
	Check pump; check frit; avoid evaporation or degradation of mobile phase
	Use column thermostat
	Replace column; use guard column

LC Troubleshooting

Problem	Possible cause
Retention times changing	Flow rate varying
	Insufficient column equilibration
	Insufficient buffer capacity
	Mobile phase composition changing; poor mixing
	Column temperature varying
	Contamination build up
	Change in column activation
Differences in selectivity	Different in mobile phase composition
	Too weak solvent
	Sample dissolved in wrong solvent
	Decreasing column life; contamination
	Temperature varying
	Column to column reproducibility

Sample preparation

Routine laboratory work involves purifying, enriching or separating for subsequent analysis. The number of samples to be analysed is constantly on the increase: Comprehensive control of the most important parameters helps to ensure product quality, prevent damage and maintain quality of life. In order to be able to utilise the possibilities offered by instrument analysis, the sample must be optimally prepared. This is often the most time consuming and critical step of the entire analysis. Selective and specific sample preparation ensures rational, economic and meaningful analysis.

The goals of sample preparation are:

- The removal of interfering sample components.
- Selective enrichment of the substances to be analysed.

If no sample preparation is carried out, the HPLC as well as the GC column may become blocked and in extreme cases this can lead to the irreversible adsorption of substances onto the column.
Analyte enrichment can increase the detection sensitivity of the detector by a factor of 100 to 5,000. Only then can the substances be identified and quantitatively determined in the required concentration range.

	Solution
	Fix leaks; replace pump seals; remove bubbles; check for phase
	Equilibrate with at least 10 column volume of mobile phase
	Use buffer concentration > 20 mM and < 50 mM
	Check pump; check frit; avoid evaporation or degradation of mobile phase
	Use solumn thermostat
	Flush column
	Condition column with initial injection of concentrated of mobile
	Check pump; check frit; avoid evaporation or degradation of mobile
	Use buffer or ion-pair system
	Dissolve sample in mobile phase or (if not possible) inject very small sample volume (1 µl)
	Replace column; improve sample cleanup; check column with test mixture; use HPLC-grade solvent
	Use column thermostat
	Replace column; check with manufacturer

Merck offers a wide range of products with absorptive, filtration and clarification properties.

- **LiChrolut®** for solid-phase extraction: as sorbents and extraction columns available
- **Extrelut® NT** for liquid-liquid extraction: as sorbents and columns specially for preparation of aqueous matrices available.
- **LiChrospher® ADS** only as column available for LC-integrated solid-phase extraction.


400 ml
50
100
150
200
250

Organic solvents

Organic solvents
properties and drying

Solvent
Acetone
Acetic acid
Acetic anhydride
Acetonitrile
Aniline
Anisole
Benzene
1-Butanol
2-Butanol
tert-Butanol
n-Butyl acetate
Carbon disulfide
Carbon tetrachloride
Chlorobenzene
Chloroform
Cyclohexane
Decahydronaphthalene (Dekalin)
Dichloromethane (Methylene chloride)
Diethyl carbonate
Diethylene
Diethylene
Diethylene glycol dimethyl ether
Diethyl ether
Diisopropyl ether
Dimethyl formamide
Dimethyl sulfoxide

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

Organic solvents
properties and drying

Solvent	Boiling point [°C]	$D^{20°}_{4°}$	$n^{20°}_{D}$	Flash point [°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.

Chemical Characteristics (Safety)
Forms explosive peroxides on contact with air, if they become concentrated, these peroxides may present an explosion hazard. Hazardous polymerization will not occur.

Ethanol–water mixtures

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

H_2SO_4 [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

Elutropic series	Cat. No.	Polarity index acc. to Snyder (1)	Formula	Molar mass [g/mol]	Refractive index $n^{20°}_{D}$	Boiling point [°C]
n-Heptane	104390	-	C_7H_{16}	100.21	1.388	98.4
n-Hexane	104391	0.0	C_6H_{14}	86.18	1.375	68.9
Cyclohexane	102827	0.0	C_6H_{12}	84.16	1.427	80.7
Isooctane	104717	0.4	C_8H_{18}	114.23	1.392	99.2
Toluene	108327	2.3	$C_6H_5CH_3$	92.14	1.496	110.6
Chloroform	102444	3.4	$CHCl_3$	119.38	1.446	61.7
Dichloromethane	106044	3.4	CH_2Cl_2	84.93	1.424	40.0
1,2-Dichloroethane	113713	3.7	$ClCH_2CH_2Cl$	98.97	1.445	83.4
1-Butanol	101988	3.9	$CH_3(CH_2)_3OH$	74.12	1.399	117.2
Tetrahydrofuran	108101	4.2	C_4H_8O	72.11	1.405	66.0
2-Propanol	101040	4.3	$CH_3CH(OH)CH_3$	60.10	1.378	82.4
Ethylacetate	100868	4.3	$CH_3COOC_2H_5$	88.10	1.372	77.1
1,4-Dioxane	103132	4.8	$C_4H_8O_2$	88.11	1.422	101.0
Ethanol	111727	5.2	C_2H_5OH	46.07	1.361	78.5
Acetone	100020	5.4	CH_3COCH_3	58.08	1.359	56.2
Acetonitrile	100030	6.2	CH_3CN	41.05	1.344	81.6
Methanol	106007	6.6	CH_3OH	32.04	1.329	65.0
Water	115333	9.0	H_2O	18.01	1.333	100.0

(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.

LiChrosolv® Acetonitrile gradient grade for liquid chromatography in 1, 2.5 and 4 l glass bottles.

Vapor pressure [hPa] (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] or [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 (2) migration distance [mm] 50	70	100
48	0.40	0.33	20.4	500	1.9	0	0.01	9.2	10.6	11.4
160	0.31	0.26	18.4	50	1.9	0	0.01	12.5	13.9	14.6
104	0.94	0.71	25.5	200	2.0	0	0.04	5.4	6.3	6.7
51	0.51	0.50	–	500	1.9	0	0.01	7.9	8.3	8.7
29	0.58	0.47	28.5	50	2.4	0.36	0.29	8.3	9.3	11.0
210	0.56	0.47	27.1	10	7.15	1.74	0.40	9.0	10.5	11.6
453	0.43	0.36	26.5	100	9.1	1.60	0.42	10.1	11.8	13.2
87	0.80	0.65	24.2	A (3)	10.6	1.75	0.44	7.6	8.4	8.9
67	2.95	1.78	24.6	100	17.8	1.66	0.7	–	–	–
200	0.47	0.38	–	50	7.4	1.63	0.57	10.9	11.9	12.6
43	2.27	1.35	21.7	200	18.3	1.66	0.82	2.1	2.3	2.5
97	0.44	0.36	23.9	400	6.0	1.78	0.59	9.2	10.9	12.1
41	1.21	0.92	33.7	20	2.2	0.40	0.56	5.2	6.0	6.5
59	1.20	0.83	22.8	1000	24.3	1.70	0.88	3.4	3.9	4.2
233	0.32	0.27	23.7	500	20.7	2.70	2.88	12.7	14.7	16.2
97	0.39	–	29.3	40	37.5	3.44	3.92	12.6	14.0	15.4
128	0.52	0.45	22.6	200	32.6	1.70	0.95	5.6	6.5	7.1
23	0.95	0.65	72.8	–	80.2	1.85	–	5.1	5.7	5.8

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 ≙ 25,000 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

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

Direct-current polarography

Half-wave potentials of some important metals

Metal	Half-wave potential [V]	Support electrolyte / concentration
Cu^{2+}	– 0.42	NH_4CH_3COO 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


150kg
Weight

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	9.8692	10197.16	750.062	14.5038
1 atm	101325	101325	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 = 7.50062·10–3 Torr 10 psi = 0.68046 atm

Decimal units multiples and subdivisions

Prefix		Symbol
10^{18}	Exa	E
10^{15}	Peta	P
10^{12}	Tera	T
10^{9}	Giga	G
10^{6}	Mega	M
10^{3}	Kilo	k
10^{2}	Hecto	h
10	Deca	da

Prefix		Symbol
10^{-1}	Deci	d
10^{-2}	Centi	c
10^{-3}	Milli	m
10^{-6}	Micro	µ
10^{-9}	Nano	n
10^{-12}	Piko	p
10^{-15}	Femto	f
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 : 1 million	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 million	1×10^{-8}	0.000 001	0.000 01	0.01	10	
1 : 1 milliard	1×10^{-9}	0.000 000 1	0.000 001	0.001	1	1 000
1 : 10 milliard	1×10^{-10}				0.1	100
1 : 100 milliard	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	Further units 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	$mol \cdot kg^{-1}$		$mol \cdot g^{-1}$	
Temperature					
Temperature	Kelvin	K	Degree centigrade	°C	

Derived units
with conversion of previous units

Size	SI unit Name	Symbol	Further units Name	Further units Symbol	Relationship
Time					
Time	second	s			
Time interval			minute	min	1 min = 60 s
			hour	h	1 h = 60 min
			day	d	1 d = 24 h
Frequency	Hertz	Hz			1 Hz = 1 s^{-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 Pa·s = 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	Further units Symbol	Relationship
Force, energy, power					
Force	Newton	N			1 N = 1 kg·m·s^{-2}
Pressure	Newton per square meter	N·m^{-2}			
	Pascal	Pa			1 Pa = 1 N·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·m^{2}·s^{-2}
			Kilowatt-hour	kW·h	1 kW·h = 3,6 MJ
Power	Watt	W			1 W = 1 J·s^{-1} = 1 N·ms^{-1} = 1 VA
Electrical measures					
Electric current	Ampere	A			
Electric potential	Volt	V			
Electric conductance	Siemens	S			1 S = 1 A·V^{-1}
Electric resistance	Ohm	V			1 V = 1 V·A^{-1} = 1 S^{-1}
Electric charge	Coulomb	C			1 C = 1 A·s
			Ampere-hour	A x h	1 A·h = 3600 A·s
Electric capacitance	Farad	F			1 F = 1 C·V^{-1}
Luminous intensity					
Luminous intensity	Candela	cd			
Luminous flux	Lumen	lm			1 lm = 1 cd·sr
Illuminance	Lux	lx			1 lx = 1 lm·m^{-2} 1 cd·sr·m^{-2}

Derived units
with conversion of previous units

Size	SI unit Name	Symbol	Further units		Relationship
			Name	Symbol	
Ionizing radiation					
Activity	Becquerel	Bq			1 Bq = 1 s^{-1}
			Curie	Ci	1 Ci = 37 G Bq
Enzymatic activity					
Enzymatic activity	Katal	kat			1 kat = 1 mol·s^{-1} = 60 mol·min^{-1}
			Enzyme unit	U	1 U = 1 mol·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	–	$\frac{a \cdot 8}{10}$	$\frac{a \cdot 8}{10} + 32$
b° Réaumur	$\frac{b \cdot 10}{8}$	–	$\frac{b \cdot 10}{8} + 32$
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		

find the derivat

$$\frac{g(x+h)-g(x)}{(x+h)-x} = \frac{g(x+h)-g(x)}{h}$$

$$f'(x) = \lim_{h\to 0} \frac{f(x+h)-}{h}$$

$$f(x) = \lim_{h\to 0} \frac{(x+h)^2-x}{h}$$

$$= \lim_{h\to 0} \frac{x^2+2xh+h^2-}{h}$$

$$\lim 2xh+h^2$$

Other useful tables

Physical constants

Constant	Symbol	Value			
Atomic mass unit	m_u	1.660540	·	10^{-27}	kg
Avogadro constant	N_A	6.022137	·	10^{23}	mol^{-1}
Bohr magneton	μ_B	9.274015	·	10^{-24}	JT^{-1}
Bohr radius	α_0	5.291771	·	10^{-11}	m
Boltzmann constant	k_B	1.380662	·	10^{-23}	JK^{-1}
Compton wavelength (e)	λ_{Ce}	2.426311	·	10^{-12}	m
Compton wavelength (n)	λ_{Cn}	1.319591	·	10^{-15}	m
Compton wavelength (p)	λ_{Cp}	1.321410	·	10^{-15}	m
Electric field constant in vacuo	ε_0	8.854188	·	10^{-12}	Fm^{-1}
Electron radius	r_e	2.817941	·	10^{-15}	m
Elementary charge	e	1.602177	·	10^{-19}	C
Faraday constant	F	9.648531	·	10^{4}	$Cmol^{-1}$
Fine structure constant	α	7.297353	·	10^{-3}	
Gas constant	R	8.31451			$Jmol^{-1}K^{-1}$
Gravitation constant	f	6.672590	·	10^{-11}	Nm^2kg^{-2}
Intrinsic impedance	Z_0	3.767301	·	10^{2}	V
Light velocity in vacuo	c	2.997924	·	10^{8}	ms^{-1}
Loschmidt constant	N_L	2.686763	·	10^{25}	m^{-3}
Magnetic field constant in vacuo	μ_0	1.256637	·	10^{-7}	Hm^{-1}
Molar volume of ideal gases 298 K, 101.325 kPa	nm	2.445294	·	10^{-2}	m^3mol^{-1}
Normal acceleration of fall	g	9.80665			ms^{-2}
Planck constant	h	6.626075	·	10^{-34}	Js
Rest mass of the electron	m_e	9.109390	·	10^{-31}	kg
Rest mass of the neutron	m_n	1.674929	·	10^{-27}	kg
Rest mass of the proton	m_p	1.672623	·	10^{-27}	kg
Rotational quantum	$h/(2\pi)$	1.054588	·	10^{-34}	Js
ydberg constant	R_∞	1.097373	·	10^{7}	m^{-1}

Creation 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		álpha	a
B		béta	b
		gámma	g
		délta	d
E		épsilon	e (short)
Z		zéta	z
H		éta	e (long)
		théta	th
I		ióta	i
K		káppa	k
		lámbda	l
M	μ	mü	m
N		nü	n
		xi	x
O		ómicron	o (short)
		pi	p
P		rho	r
	1, 2	sigma	s
		tau	t
		ýpsilon	y
		phi	ph
		chi	ch
		psi	ps
		ómega	o (long)

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

Greek numbers / 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

Name	Cat. No.	Notes on use
Extran® MA 01 alkaline / liquid	107555	Universal cleaning agent for heavy contamination. For hard water even up to 40° d. For cleaning tables, tiles, and floors in the laboratory. Suitable for ultrasonic cleaning.
Extran® MA 02 neutral / liquid	107553	Special cleaner for precision instruments of glass, quartz and sensitive metals. Suitable for ultrasonic cleaning.
Extran® MA 03 phosphate-free liquid	107550	Universal cleaning agent for heavy contamination. With very hard water also usable without restrictions. Environmentally friendly as it contains no phosphate. Suitable for ultrasonic cleaning.
Extran® MA 05 liquid / alkaline / phosphatefree concentrate	140000	Universal cleaning agent for heavy contamination. With very hard water also usable without restrictions. Environmentally friendly as it contains no phosphate and NTA*. Suitable for ultrasonic cleaning.
Extran® AP 11 mildly alkaline / powder	107558	Gentle cleaning action; e.g. in the analytical laboratory. Cleaning action equivalent to that of AP 14 liquid.
Extran® AP 12 alkaline / powder	107563	Powerful cleaning action. Particularly with starch and protein residues. Cleaning action equivalent to that of AP 15 liquid.
Extran® AP 13 alkaline with detergents / powder	107565	Powerful cleaning action. Particularly with fat residues.
Extran® AP 14 mildly alkaline / liquid	107573	Gentle cleaning action for machines with liquid dosing; e.g. in the analytical laboratory. Environmentally friendly as it contains no phosphate. Cleaning action equivalent to that of AP 11 powder.

Extran® laboratory cleaning agents

Name	Cat. No.	Notes on use
Extran® AP 15 alkaline / liquid	107575	Powerful cleaning for machines with liquid dosing. Environmentally friendly as it contains no phosphate. Cleaning action equivalent to that of AP 12 powder.
Extran® AP 16 liquid / mildly alkaline concentrate	140001	Gentle cleaning action for machines with liquid dosing; e.g. in the analytical laboratory. Environmentally friendly as it contains no phosphate and NTA*. Cleaning action equivalent to that of AP 11 powder.
Extran® AP 17 acidic with phosphoric acid liquid	140006	Powerful cleaning for machines with liquid dosing. Environmentally friendly as it contains no phosphate and NTA*. Cleaning action equivalent to that of AP 12 powder.
Extran® AP 21 acidic with phosphoric acid liquid	107559	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.
Extran® AP 22 acidic with citric acid liquid	107561	Gentle prerinse or final rinse with neutralizing action. Prevents the formation of calcareous deposits. Environmentally friendly as it contains no phosphate.
Extran® AP 31 antifoam/ liquid	107560	Additive for foam-forming residues: proteins, fats, emulsifiers of all types.
Extran® AP 33 liquid / anti-foaming agent / formaldehyde-free	140007	Additive for foam-forming residues: proteins, fats, emulsifiers of all types. Environmentally friendly as it contains no formaldehyde.
Extran® AP 41 enzymatic / powder	107570	For medical and dental practices, anaesthetic equipment. For the removal of mucus, saliva, blood etc. Temperature: 55 – 65 °C.

* NTA = Nitrilotriacetic Acid

Extran® cleaning agents in renowned Merck quality are the key to reliable cleaning of your labware

Merck provides its high-quality Extran® cleaning agents for more than 25 years now.

The benefits to you:

- *Extran cleans reliably without leaving any residues performed.*
- *Extran is free from scented materials, colorants, chlorine and toxic ingredients.*
- *Its active ingredients are biodegradable, so environmental demands are met.*

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				

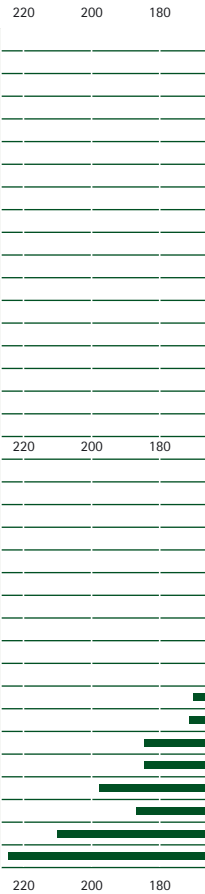
Particle sizes

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

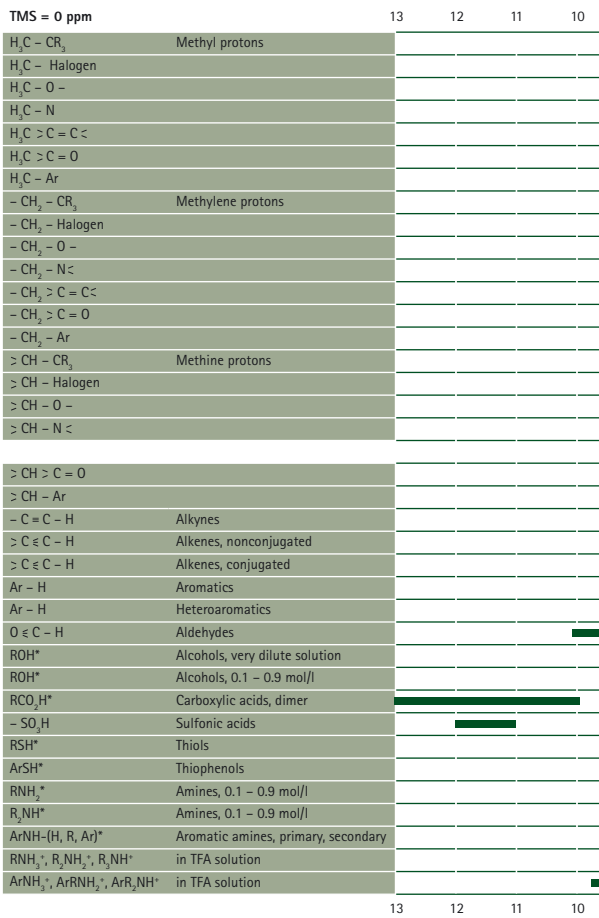
NMR: Carbon (13C) chemical shifts

TMS = 0 ppm	
$H_3C - C \leqslant$	C primary
H_3C – Halogen	
$H_3C - O -$	
$H_3C - N <$	
$H_3C - S -$	
$- CH_2 - C \leqslant$	C secondary
$- CH_2$ – Halogen	
$- CH_2 - O -$	
$- CH_2 - N <$	
$- CH_2 - S -$	
$> CH - C \leqslant$	C tertiary
$> CH$ – Halogen	
$> CH - O -$	
$> CH - N <$	
$> CH - S -$	
$\geqslant C - C \leqslant$	C quaternary
$\geqslant C$ – Halogen	
$\geqslant C - O -$	
$> C - S \leqslant$	
$\geqslant C - C -$	Alkanes
$- C \equiv C -$	Alkynes
$> C = C <$	Alkenes
$> C = C <$	Aromatics
$> C = C <$	Heteroaromatics
$- O - C \equiv N$	Cyanates
$- S - C \equiv N$	Thiocyanates
$- C \equiv N$	Cyanides
$C = N -$	Azomethines
$(- CO)_2O$	Anhydrides
– COOR	Esters
$(- CO)_2NR$	Imides
– CONHR	Amides
– COOH	Acids
– COCl	Acid Chlorides
$- C = O$	Aldehyde
$> C = O$	Ketone

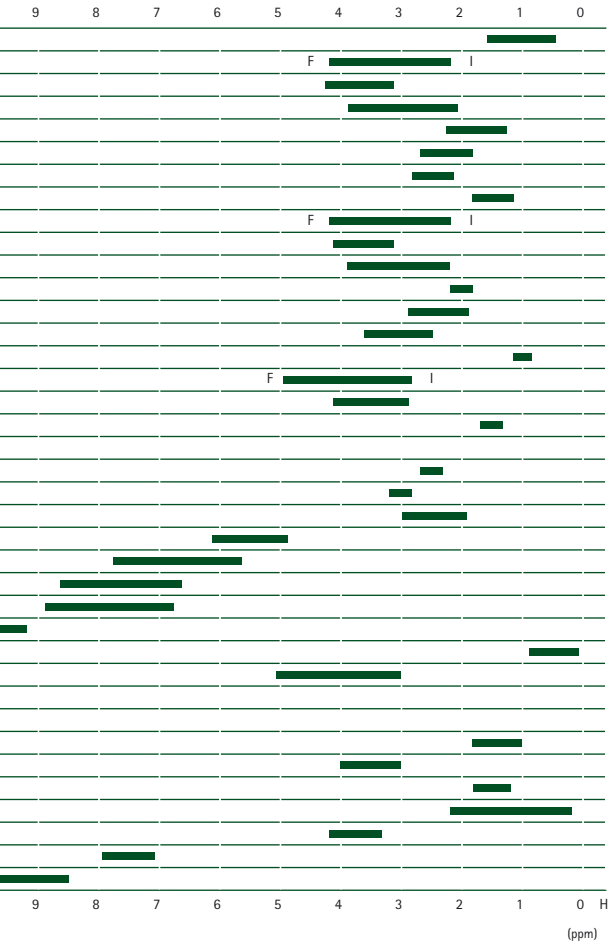



160 140 120 100 80 60 40 20 0 – 20 – 40
Cl
I
aliphates – cyclopropanes
Cl
I
Cl
I
Cl
I
160 140 120 100 80 60 40 20 0 – 20 – 40
160 140 120 100 80 60 40 20 0 – 20 – 40

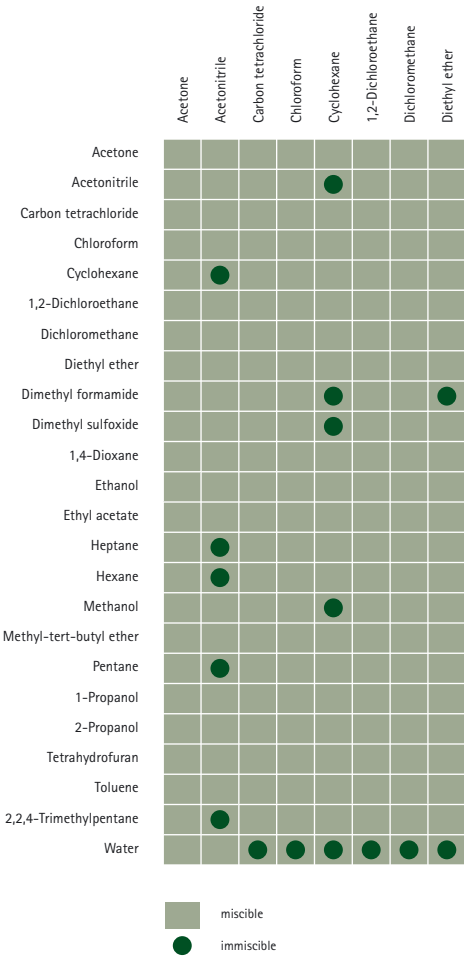
NMR: Proton chemical shifts

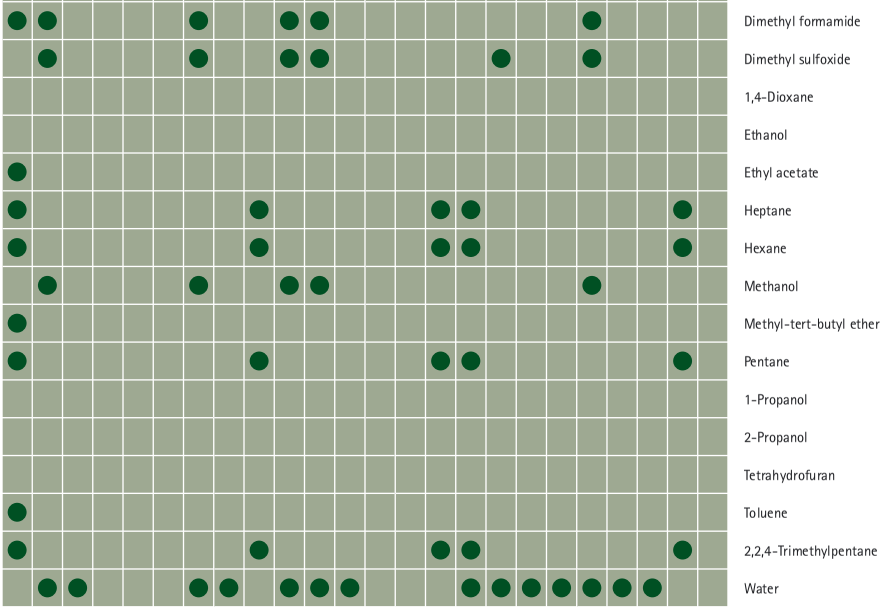


* The chemical shifts of these groups are concentration-dependent and are shifted to lower ppm values in more dilute solutions


9
8
7
6
5
4
3
2
1
0
F
I
F
I
F
I
9
8
7
6
5
4
3
2
1
0
H
(ppm)

Miscibility tables




Dimethyl formamide
Dimethyl sulfoxide
1,4-Dioxane
Ethanol
Ethyl acetate
Heptane
Hexane
Methanol
Methyl-tert-butyl ether
Pentane
1-Propanol
2-Propanol
Tetrahydrofuran
Toluene
2,2,4-Trimethylpentane
Water

Notes

For any further information
please contact your local agent

We provide information and advice to our customers to the best of our knowledge and ability, but without obligation or liability. Existing laws and regulations are to be observed in all cases by our customers. This also applies in respect to any rights of third parties. Our information and advice do not relieve our customers of their own responsibility for checking the suitability of our products for the envisaged purpose.

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