Lab Tools

Table 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

Chemicals

Performance & Life Science Chemicals

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

Liquid Crystals

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

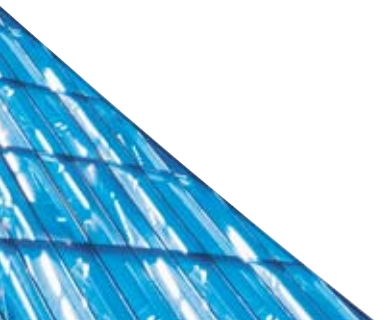
Pharmaceuticals

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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Safety in the laboratory

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

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

Each manufacturer of laboratory reagents is obliged to label reagents in accordance with the Global Harmonized System (GHS) and provide the respective material safety data sheets (MSDS).

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

The handling of hazardous chemicals demands special know-how, carefulness and adequate precautions. All use has to be performed in such a way that hazardous gases, vapors or suspended particles are - as far as technically possible - not released into the environment.

If necessary, appropriate measures have to be taken. When reaching the specific occupational exposure limits, special safety measures become necessary such as safe and practical personal protective equipment (PPE). The following rules apply to provide safety during the working process:

1. When working in a laboratory or a warehouse wear safety glasses, special working clothes or lab coat, suitable lab shoes and, where necessary, suitable gloves.

2. In any case avoid contact with skin, eyes and mucous membranes.

3. In case of contact with a chemical, rinse off any splashes on the skin with plenty of cold water; in the case of lipophilic substances rinse off with polyglycol. Due to the danger of absorption, never use other organic solvents. In doubt consult a physician as soon as possible.

4. Thoroughly rinse chemically burned eyes under a gentle stream of water or with a special eye shower. Rinse with your eyes wide open and roll your eyes in all directions. Subsequently, an eye examination must be performed. It is absolutely necessary to inform the eye specialist of the chemical used. It is also recommended to state its hazardous properties in order to decide on adequate treatment.

5. Take off immediately any clothing contaminated with chemicals.

6. In case of accidents or if you feel unwell, consult a physician and state the cause of accident including the name of the chemical involved.

7. Do not smoke, eat and drink in laboratory rooms or while working with chemicals.

What is a hazardous material?

In accordance with OSHA a hazardous material is any item or agent (biological, chemical, physical) which has the potential to cause harm to humans, animals, or the environment, either by itself or through interaction with other factors including materials which are carcinogens, toxic agents, irritants, corrosives, sensitizers; agents which act on the hematopoietic system; agents which damage the lungs, skin, eyes, or mucous membranes; chemicals which are combustible, explosive, flammable, oxidizers, pyrophorics, unstable-reactive or water-reactive; and chemicals which in the course of normal handling, use, or storage may produce or release dusts, gases, fumes, vapors, mists or smoke which may have any of the previously mentioned characteristics.

Acids in Safebreak bottles

Acids in glass bottles have hazard potential: glass can break! Our solution is the Merck Safebreak bottle – a PE-coated glass bottle. In case of a breakage the acid and any sherds are reliably held together and can be disposed easily. The bottle protects the lab staff from getting injured by the acid as well as the glass splinters. Empty bottles can be recycled as glass.

Hazard cautionary

H200	Unstable explosives.
H201	Explosive; mass explosion hazard.
H202	Explosive, severe projection hazard.
H203	Explosive; fire, blast or projection hazard.
H204	Fire or projection hazard.
H205	May mass explode in fire.
H220	Extremely flammable gas.
H221	Flammable gas.
H222	Extremely flammable aerosol.
H223	Flammable aerosol.
H224	Extremely flammable liquid and vapour.
H225	Highly flammable liquid and vapour.
H226	Flammable liquid and vapour.
H228	Flammable solid.
H240	Heating may cause an explosion.
H241	Heating may cause a fire or explosion.
H242	Heating may cause a fire.
H250	Catches fire spontaneously if exposed to air.
H251	Self-heating: may catch fire.
H252	Self-heating in large quantities; may catch fire.
H260	In contact with water releases flammable gases which may ignite spontaneously.
H261	In contact with water releases flammable gases.
H270	May cause or intensify fire; oxidiser.
H271	May cause fire or explosion; strong oxidiser.
H272	May intensify fire; oxidiser.
H280	Contains gas under pressure; may explode if heated.
H281	Contains refrigerated gas; may cause cryogenic burns or injury.
H290	May be corrosive to metals.
H300	Fatal if swallowed.
H301	Toxic if swallowed.
H302	Harmful if swallowed.
H304	May be fatal if swallowed and enters airways.
H310	Fatal in contact with skin.
H311	Toxic in contact with skin.
H312	Harmful in contact with skin.
H314	Causes severe skin burns and eye damage.
H315	Causes skin irritation.
H317	May cause an allergic skin reaction.
H318	Causes serious eye damage.
H319	Causes serious eye irritation.
H330	Fatal if inhaled.
H331	Toxic if inhaled.
H332	Harmful if inhaled.
H334	May cause allergy or asthma symptoms or breathing difficulties if inhaled.
H335	May cause respiratory irritation.
H336	May cause drowsiness or dizziness.
H340	May cause genetic defects state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard.
H341	Suspected of causing genetic defects state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard.
H350	May cause cancer state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard.

H351	Suspected of causing cancer state route of exposure if it is conclusively proven that no other routs of exposure cause the hazard.
H360	May damage fertility or the unborn child state specific effect if known state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard.
H361	Suspected of damaging fertility or the unborn child state specific effect if known state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard.
H362	May cause harm to breast-fed children.
H370	Causes damage to organs or state all organs affected, if known state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard.
H371	May cause damage to organs or state all organs affected, if known state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard.
H372	Causes damage to organs or state all organs affected, if known through prolonged or repeated exposure state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard.
H373	May cause damage to organs or state all organs affected, if known through prolonged or repeated exposure state route of exposure if it is conclusively proven that no other routes of exposure cause the hazard.
H400	Very toxic to aquatic life.
H410	Very toxic to aquatic life with long lasting effects.
H411	Toxic to aquatic life with long lasting effects.
H412	Harmful to aquatic life with long lasting effects.
H413	May cause long lasting harmful effects to aquatic life.

EU hazard cautionary

EUH001	Explosive when dry.
EUH006	Explosive with or without contact with air.
EUH014	Reacts violently with water.
EUH018	In use may form flammable/explosive vapour-air mixture.
EUH019	May form explosive peroxides.
EUH044	Risk of explosion if heated under confinement.
EUH029	Contact with water liberates toxic gas.
EUH031	Contact with acids liberates toxic gas.
EUH032	Contact with acids liberates very toxic gas.
EUH066	Repeated exposure may cause skin dryness or cracking.
EUH070	Toxic by eye contact.
EUH071	Corrosive to the respiratory tract.
EUH059	Hazardous to the ozone layer.
EUH201	Contains lead. Should not be used on surfaces liable to be chewed or sucked by children.
EUH201A	Warning! Contains lead.
EUH202	Cyanoacrylate. Danger. Bonds skin and eyes in seconds. Keep out of the reach of children.
EUH203	Contains chromium (VI). May produce an allergic reaction.
EUH204	Contains isocyanates. May produce an allergic reaction.
EUH205	Contains epoxy constituents. May produce an allergic reaction.
EUH206	Warning! Do not use together with other products. May release dangerous gases (chlorine).

EU hazard cautionary

EUH207	Warning! Contains cadmium. Dangerous fumes are formed during use. See information supplied by the manufacturer. Comply with the safety instructions.
EUH208	Contains <name of sensitising substance>. May produce an allergic reaction.
EUH209	Can become highly flammable in use.
EUH209A	Can become flammable in use.
EUH210	Safety data sheet available on request.
EUH401	To avoid risks to human health and the environment, comply with the instructions for use.

Precautionary

P101	If medical advice is needed, have product container or label at hand.
P102	Keep out of reach of children.
P103	Read label before use.
P201	Obtain special instructions before use.
P202	Do not handle until all safety precautions have been read and understood.
P210	Keep away from heat/sparks/open flames/hot surfaces. — No smoking.
P211	Do not spray on an open flame or other ignition source.
P220	Keep/Store away from clothing/.../combustible materials.
P221	Take any precaution to avoid mixing with combustibles...
P222	Do not allow contact with air.
P223	Keep away from any possible contact with water, because of violent reaction and possible flash fire.
P230	Keep wetted with...
P231	Handle under inert gas.
P232	Protect from moisture.
P233	Keep container tightly closed.
P234	Keep only in original container.
P235	Keep cool.
P240	Ground/bond container and receiving equipment.
P241	Use explosion-proof electrical/ventilating/lighting/.../equipment.
P242	Use only non-sparking tools.
P243	Take precautionary measures against static discharge.
P244	Keep reduction valves free from grease and oil.
P250	Do not subject to grinding/shock/.../friction.
P251	Pressurized container: Do not pierce or burn, even after use.
P260	Do not breathe dust/fume/gas/mist/vapours/spray.
P261	Avoid breathing dust/fume/gas/mist/vapours/spray.
P262	Do not get in eyes, on skin, or on clothing.
P263	Avoid contact during pregnancy/while nursing.
P264	Wash ... thoroughly after handling.
P270	Do no eat, drink or smoke when using this product.
P271	Use only outdoors or in a well-ventilated area.
P272	Contaminated work clothing should not be allowed out of the workplace.
P273	Avoid release to the environment.
P280	Wear protective gloves/protective clothing/eye protection/face protection.
P281	Use personal protective equipment as required.
P282	Wear cold insulating gloves/face shield/eye protection.
P283	Wear fire/flame resistant/retardant clothing.
P284	Wear respiratory protection.

P285	In case of inadequate ventilation wear respiratory protection.
P231/232	Handle under inert gas. Protect from moisture.
P235/410	Keep cool. Protect from sunlight.
P301	IF SWALLOWED:
P302	IF ON SKIN:
P303	IF ON SKIN (or hair):
P304	IF INHALED:
P305	IF IN EYES:
P306	IF ON CLOTHING:
P307	IF exposed:
P308	IF exposed or concerned:
P309	IF exposed or if you feel unwell:
P310	Immediately call a POISON CENTER or doctor/physician.
P311	Call a POISON CENTER or doctor/physician.
P312	Call a POISON CENTER or doctor/physician if you feel unwell.
P313	Get medical advice/attention.
P314	Get medical advice/attention if you feel unwell.
P315	Get immediate medical advice/attention.
P320	Specific treatment is urgent (see ... on this label).
P321	Specific treatment (see ... on this label).
P322	Specific measures (see ... on this label).
P330	Rinse mouth.
P331	Do NOT induce vomiting.
P332	If skin irritation occurs:
P333	If skin irritation or rash occurs:
P334	Immerse in cool water/wrap in wet bandages.
P335	Brush off loose particles from skin.
P336	Thaw frosted parts with lukewarm water. Do no rub affected area.
P337	If eye irritation persists:
P338	Remove contact lenses, if present and easy to do. Continue rinsing.
P340	Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P341	If breathing is difficult, remove victim to fresh air and keep at rest in a position comfortable for breathing.
P342	If experiencing respiratory symptoms:
P350	Gently wash with plenty of soap and water.
P351	Rinse cautiously with water for several minutes.
P352	Wash with plenty of soap and water.
P353	Rinse skin with water/shower.
P360	Rinse immediately contaminated clothing and skin with plenty of water before removing clothes.
P361	Remove/Take off immediately all contaminated clothing.
P362	Take off contaminated clothing and wash before reuse.
P363	Wash contaminated clothing before reuse.
P370	In case of fire:
P371	In case of major fire and large quantities:
P372	Explosion risk in case of fire.
P373	DO NOT fight fire when fire reaches explosives.
P374	Fight fire with normal precautions from a reasonable distance.
P375	Fight fire remotely due to the risk of explosion.
P376	Stop leak if safe to do so.
P377	Leaking gas fire: Do not extinguish, unless leak can be stopped safely.
P378	Use ... for extinction.
P380	Evacuate area.
P381	Eliminate all ignition sources if safe to do so.

Precautionary

P390	Absorb spillage to prevent material damage.
P391	Collect spillage.
P301/310	IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician.
P301/312	IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell.
P301/330/331	IF SWALLOWED: rinse mouth. Do NOT induce vomiting.
P302/334	IF ON SKIN: Immerse in cool water/wrap in wet bandages.
P303/350	IF ON SKIN: Gently wash with plenty of soap and water.
P302/352	IF ON SKIN: Wash with plenty of soap and water.
P303/361/353	IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower.
P304/340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P304/341	IF INHALED: If breathing is difficult, remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305/351/338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P306/360	IF ON CLOTHING: rinse immediately contaminated clothing and skin with plenty of water before removing clothes.
P307/311	IF exposed: Call a POISON CENTER or doctor/physician.
P308/313	IF exposed or concerned: Get medical advice/attention.
P309/311	IF exposed or if you feel unwell: Call a POISON CENTER or doctor/physician.
P332/313	If skin irritation occurs: Get medical advice/attention.
P333/313	If skin irritation or rash occurs: Get medical advice/attention.
P335/334	Brush off loose particles from skin. Immerse in cool water/wrap in a wet bandages.
P337/313	If eye irritation persists: Get medical advice/attention.
P342/311	If experiencing respiratory symptoms: Call a POISON CENTER or doctor/physician.
P370/376	In case of fire: Stop leak if safe to do so.
P370/378	In case of fire: Use ... for extinction.
P370/380	In case of fire: Evacuate area.
P370/380/375	In case of fire: Evacuate area. Fight fire remotely due to the risk of explosion.
P371/380/375	In case of major fire and large quantities: Evacuate area. Fight fire remotely due to the risk of explosion.
P401	Store ...
P402	Store in a dry place.
P403	Store in a well-ventilated place.
P404	Store in a closed container.
P405	Store locked up.
P406	Store in corrosive resistant/... container with a resistant inner liner.
P407	Maintain air gap between stacks/pallets.
P410	Protect from sunlight.
P411	Store at temperatures not exceeding ... °C/...°F.
P412	Do not expose to temperatures exceeding 50 °C/122°F.
P413	Store bulk masses greater than ... kg/... lbs at temperatures not exceeding ... °C/...°F.
P420	Store away from other materials.
P422	Store contents under ...
P402/404	Store in a dry place. Store in a closed container.
P403/233	Store in a well-ventilated place. Keep container tightly closed.
P403/235	Store in a well-ventilated place. Keep cool.
P410/403	Protect from sunlight. Store in a well-ventilated place.

P410/412	Protect from sunlight. Do no expose to temperatures exceeding 50 °C/122°F.
P411/235	Store at temperatures not exceeding ... °C/...°F. Keep cool.
P501	Dispose of contents/container to ...

Chemizorb - absorbents for spilled liquids

Mishaps and accidents happen - every day and nearly in every lab! With Chemizorb® you can remove spilled liquids quickly and safely. Chemizorb® is capable of taking up 100 to 400 percent (depending on the type) of their own weight in liquid material. Merck offers you specific absorbents for each problem:
- the „allrounders", Chemizorb® powder and granules,
- the „specialists", Chemizorb® Alkalis, Acid, Hydrofluoric Acid, and also
- the „all-in-one" Chemizorb® Mercury set

Hazard symbols

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

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

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

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

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

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

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

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

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

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

Risk (R) phrases

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

R57	Toxic to bees.
R58	May cause long-term adverse effects in the environment.
R59	Dangerous for the ozone layer.
R60	May impair fertility.
R61	May cause harm to the unborn child.
R62	Possible risk of impaired fertility.
R63	Possible risk of harm to the unborn child.
R64	May cause harm to breastfed babies.
R65	Harmful: May cause lung damage if swallowed.
R66	Repeated exposure may cause skin dryness and dizziness.
R67	Vapours may cause tiredness and lightheadedness.
R68	Possible risks of irreversible effects.

Combination of risk phrases

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

Risk (R) phrases

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

R 48/23	Toxic: danger of serious damage to health by prolonged exposure through inhalation.
R 48/23/24	Toxic: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin.
R 48/23/ 24/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.
R 48/23/25	Toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.
R 48/24	Toxic: danger of serious damage to health by prolonged exposure in contact with skin.
R 48/24/25	Toxic: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed.
R 48/25	Toxic: danger of serious damage to health by prolonged exposure if swallowed.
R 50/53	Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
R 51/53	Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
R 52/53	Harmful to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Risk phrases with supplements

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

Risk (R) phrases

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

R E48/20/21	Also harmful: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin.
R E48/20/ 21/22	Also harmful: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.
R E48/20/22	Also harmful: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.
R E48/21	Also harmful: danger of serious damage to health by prolonged exposure in contact with skin.
R E48/21/22	Also harmful: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed.
R E48/22	Also harmful: danger of serious damage to health by prolonged exposure if swallowed.
R E48/23	Also toxic: danger of serious damage to health by prolonged exposure through inhalation.
R E48/23/24	Also toxic: danger of serious damage to health by prolonged exposure through inhalation and in contact with skin.
R E48/23/ 24/25	Also toxic: danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed.
R E48/23/25	Also toxic: danger of serious damage to health by prolonged exposure through inhalation and if swallowed.
R E48/24	Also toxic: danger of serious damage to health by prolonged exposure in contact with skin.
R E48/24/25	Also harmful: danger of serious damage to health by prolonged exposure in contact with skin and if swallowed.
R E48/25	Also toxic: danger of serious damage to health by prolonged exposure if swallowed

Acid in Safebreak bottle

Safety (S) phrases

S 1	Keep locked up.
S 2	Keep out of reach of children.
S 3	Keep in a cool place.
S 4	Keep away from living quarters.
S 5	Keep contents under ... (appropriate liquid to be specified by the manufactures)
S 6	Keep contents under ... (inert gas to be specified by the manufacturer).
S 6.1	Keep under nitrogen.
S 7	Keep container tightly closed.
S 8	Keep container dry.
S 9	Keep container in a well-ventilated place.
S 12	Do not keep the container sealed.
S 13	Keep away from food, drink and animal feeding stuffs.
S 14	Keep away from ... (incompatible materials to be indicated by the manufactures)
S 14.1	Keep away from reducing agents, heavy metal compounds, acids and alkalis.
S 14.10	Keep away from acids, reducing agents and flammable material.
S 14.11	Keep away from flammable material.
S 14.2	Keep away from oxidizing and acidic substances as well as heavy metal compounds.
S 14.3	Keep away from iron.
S 14.4	Keep away from water and alkalis.
S 14.5	Keep away from acids.
S 14.6	Keep away from alkalis.
S 14.7	Keep away from metals.
S 14.8	Keep away from oxidizing and acidic substances.
S 14.9	Keep away from flammable organic substances.
S 15	Keep away from heat.
S 16	Keep away from sources of ignition - No smoking.
S 17	Keep away from combustible material.
S 18	Handle and open container with care.
S 20	When using do not eat or drink.
S 21	When using do not smoke.
S 22	Do not breathe dust.
S 23	Do not breathe gas/fumes/vapour/spray
S 23.1	Do not breathe gas.
S 23.2	Do not breathe vapour.
S 23.3	Do not breathe spray.
S 23.4	Do not breathe fumes.
S 23.5	Do not breathe fumes/spray.
S 24	Avoid contact with skin.
S 25	Avoid contact with eyes.
S 26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S 27	Take off immediately all contaminated clothing.
S 28	After contact with skin, wash immediately with plenty of... (to be specified by the manufactures)
S 28.1	After contact with skin, wash immediately with plenty of water.
S 28.2	After contact with skin, wash immediately with plenty of soap and water.
S 28.3	After contact with skin, wash immediately with plenty of soap and water, if possible also with polyethylene glycol 400.

S 28.4	After contact with skin, wash immediately with plenty of polyethylene glycol 300 and ethanol (2:1) followed by plenty of soap and water.
S 28.5	After contact with skin, wash immediately with plenty of polyethylene glycol 400.
S 28.6	After contact with skin, wash immediately with plenty of polyethylene glycol 400, then rinse with plenty of water.
S 28.7	After contact with skin, wash immediately with plenty of water and acidic soap.
S 29	Do not empty into drains.
S 30	Never add water to this product.
S 33	Take precautionary measures against static discharges.
S 35	This material and its container must be disposed of in a safe way.
S 36	Wear suitable protective clothing.
S 37	Wear suitable gloves.
S 38	In case of insufficient ventilation, wear suitable respiratory equipment.
S 39	Wear eye/face protection.
S 40	To clean the floor and all objects contaminated by this material use... (to be specified by the manufacturer).
S 41	In case of fire and/or explosion do not breathe fumes.
S 42	During fumigation/spraying with wear suitable respiratory equipment.
S 43	In case of fire, use ... (indicate the precise type of fire-fighting equipment. If water increases risk, add -'Never use water'.
S 43.1	In case of fire, use water.
S 43.2	In case of fire, use water or powder extinguisher.
S 43.3	In case of fire, use powder extinguisher. Never use water.
S 43.4	In case of fire, use CO2 - never use water.
S 43.6	In case of fire, use sand - never use water.
S 43.7	In case of fire, use metal fire powder - never use water.
S 43.8	In case of fire, use sand, CO2 or powder extinguisher, never use water.
S 45	In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
S 46	If swallowed, seek medical advice immediately and show this container or label.
S 47	Keep at temperature no exceeding ...°C (to be specified by the manufacturer).
S 47.1	Keep at temperature no exceeding 20°C.

Safety (S) phrases

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

Combination of safety phrases

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

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

Safety (S) phrases

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

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GHS – the first-ever globally uniform basis

GHS stands for the Globally Harmonised System of Classification and Labelling of Chemicals. In December 2002, the United Nations published the GHS in the so-called "Purple Book" with a description of harmonised classification and labelling criteria. The goal of GHS is to harmonise the various existing classification and labelling systems all over the world. Because of the various evaluation criteria, it has long been the case that one and the same substance can be classified as poisonous, harmful to health, or even not harmful. This leads to different levels of protection in terms of occupational health and safety, consumer protection, and environmental protection. GHS offers the first-ever globally uniform basis for the evaluation of substance properties. GHS establishes the requirement for a globally high protection level for human health and the environment.
The resulting harmonised hazard communication includes criteria for classification and labelling as well as hazardous substance labelling and requirements for the creation of Safety Data Sheets.

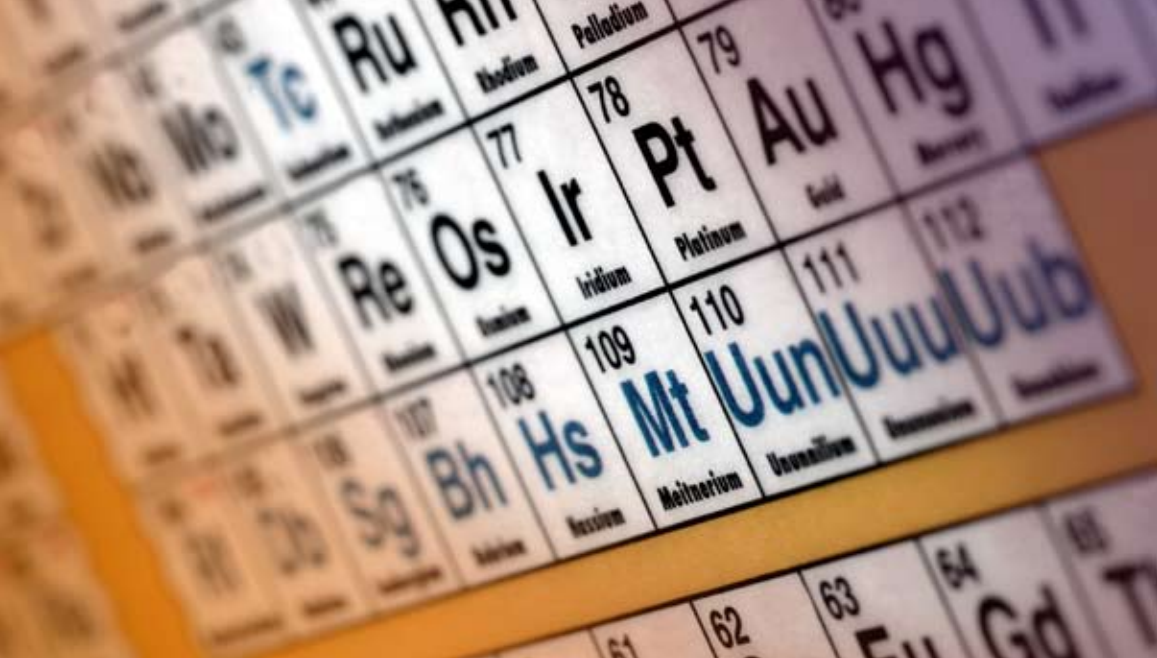
for more information visit
www.merck-chemicals.com/ghs

Incompatible chemicals

The chemicals listed below may react violently with one another. They must be kept apart and must never come into contact with one another. The objective of this list is to give information on how to avoid accidents in the laboratory.
Due to the great number of hazardous materials, this list includes only the most important examples.

Substance	Incompatible with
Acetylene	halogen, copper, silver, mercury, air, oxidant, oxygen, silver compound, mercury compound, copper compound and heavy metal salts
Acetic acid	chromium (VI) oxide, nitric acid, alcohols, ethylene glycol, perchloric acid, peroxides, permanganates, alkali, base, cyanide
Activated carbon	calcium hypochlorite, oxidizing agents, alcohols, acids, organic nitro compound and oxidant
Alkali metals	water, carbon tetrachloride and other halogenated alkanes, carbon dioxide, halogens
Aluminum alkyls	water, alcohols, oxidant and acids
Ammonia (laboratory gas or solutions)	mercury (e.g. in pressure gauges), calcium hypochlorite, hydrogen fluoride, halogen, acids, air and oxygen
Ammonium nitrate	acids, powdered metals, flammable liquids, chlorates, sulfur, fine-particulate organic or combustible materials, alkali metals, base, oils, reducing agent, potassium dichromate
Aniline	nitric acid, hydrogen peroxide Oxidationsmittel, Säure
Bromine	see chlorine
Chlorine	ammonia, acetylene, butadiene, butane, methane, propane, hydrogen, petroleum benzine, benzene, powdered metals, phosphor
Chlorates	ammonium salts, acids, powdered metals, sulfur, fine-particulate organic or combustible substances, azide, picrate and picric acid
Chromium (VI) oxide	acetic acid, naphthalene, camphor, glycerol, petroleum benzine, alcohols, flammable liquids
Copper	acetylene, hydrogen peroxide
Cumene hydroperoxide	acids, both organic and inorganic
Cyanides	acids
Flammable liquids	ammonium nitrate, chromium (VI) oxide, hydrogen peroxide, nitric acid, sodium peroxide, halogens, oxidant
Fluorine	extremely aggressive; store separately!
Hydrocarbon	fluorine, chlorine, bromine, (butane, propane, chromium (VI) oxide, sodium peroxide benzene etc.)
Hydrogen fluoride	ammonia (laboratory gas or solutions), alkali metals, base
Hydrogen peroxide	copper, chromium, iron, metals and metal salts, alcohols, acetone, organic substances, aniline, nitro-methane, combustible substances (solid or liquid), manganese dioxid, permanganate, ether
Hydrogen sulfide	fuming nitric acid, oxidizing gases, oxygen

Iodine	acetylene, ammonia (laboratory gas or solutions), alkali metals and ammonium compound
Mercury	acetylene, ammonia, aluminium
Nitric acid	acetic acid, aniline, chromium (VI) oxide,prussic acid, (concentrated) hydrogen sulfide, flammable liquids and gases, flammable substances, dichloromethane, organic solvents
Oxalic acid	silver, mercury, oxidant, alkalis
Perchloric acid	acetic anhydride, bismuth and its alloys, alcohols, paper, wood, flammable and organic substances, dichloromethane and organic solvents
Phosphorus	sulfur, compounds containing oxygen, e.g. chlorates, oxidant and chlorate
Potassium	see alkali metals
Potassium chlorate	see chlorate
Potassium perchlorate	see chlorate
Potassium	glycerol, ethylene glycol, benzaldehyde, sulfuric acid permanganate
Silver	acetylene, oxalic acid, tartaric acid, ammonium compounds, acetylide and azide
Sodium	see alkali metals
Sodium peroxide	methanol, ethanol, glacial acetic acid, acetic anhydride, benzaldehyde, carbon disulfide, glycerol, ethylene glycol, ethyl acetate, methyl acetate, furfural, flammable substances, metals in powder form and acids
Sulfuric acid	chorate, perchlorate, potassium permangangate, cyanide, permanganate, alkali metals, alkali compounds and base


Ru
Rhodium
Palladium
Tc
Technetium
Mo
Molybdenum
Re
Rhenium
Os
Osmium
Ir
Iridium
Pt
Platinum
Au
Gold
Hg
Mercury
W
Tungsten
Ta
Tantalum
Hf
Hafnium
Bh
Bohrium
Hs
Hassium
Mt
Meitnerium
Uun
Ununnilium
Uuu
Unununium
Uub
Ununbium
Sg
Seaborgium
Db
Dubnium
Rf
Rutherfordium
Gd
Gadolinium
Eu
Europium

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

Infotext zu Element

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Electrochemical series of some nonmetals (alkaline solution)

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

Covalent single-bond radiuses (in PM)

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

* Determined from H-X bond distances

Infotext zu Element

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

$D\frac{20°}{4°} = 1.28$. 1.28 is required. Available: concentrated

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

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

Calculation

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

$D\frac{20°}{4°} = 1.28$ equivalent to 37.36 weight%.

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

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

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 $D_{4^\circ}^{20^\circ} = 1.520$ is to be prepared from sulfuric acid with a density of $D_{4^\circ}^{20^\circ} = 1.435$ and sulfuric acid of $D_{4^\circ}^{20^\circ} = 1.824$.

Calculation

The table 'Sulfuric acid' (p. 56) informs that sulfuric acid with a density of $D_{4^\circ}^{20^\circ} = 1.435$ = 54.00 weight% H_2SO_4 contains sulfuric acid with a density of $D_{4^\circ}^{20^\circ} = 1.824$ = 92.00 weight% H_2SO_4 and that of $D_{4^\circ}^{20^\circ} = 1.520$ = 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 $D_{4^\circ}^{20^\circ} = 1.520$.

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	$AlNH_4(SO4)_2 \cdot 12H_2O$
	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	$Al2(SO_4)_3 \cdot 18H_2O$
	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. in %	Density of the total solution at 20 °C. in %
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	$MnCl2 \cdot 4H_2O$
	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. in %	Density of the total solution at 20 °C. in %
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 in %	Density of the total solution at 20 °C in %
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 in %	Density of the total solution at 20 °C in %
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, in [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, in [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, in [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°)

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Sulfuric acid

H_2SO_4 , M = 98.08 g/mol

Density $d\ ^{20°}_{4°}$	H_2SO_4 content	
	weight%	mol/l
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 $d\ ^{20^\circ}_{4^\circ}$	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 $d\ ^{20^\circ}_{4^\circ}$	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 $d_4^{20°}$	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 $d_4^{20°}$	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

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

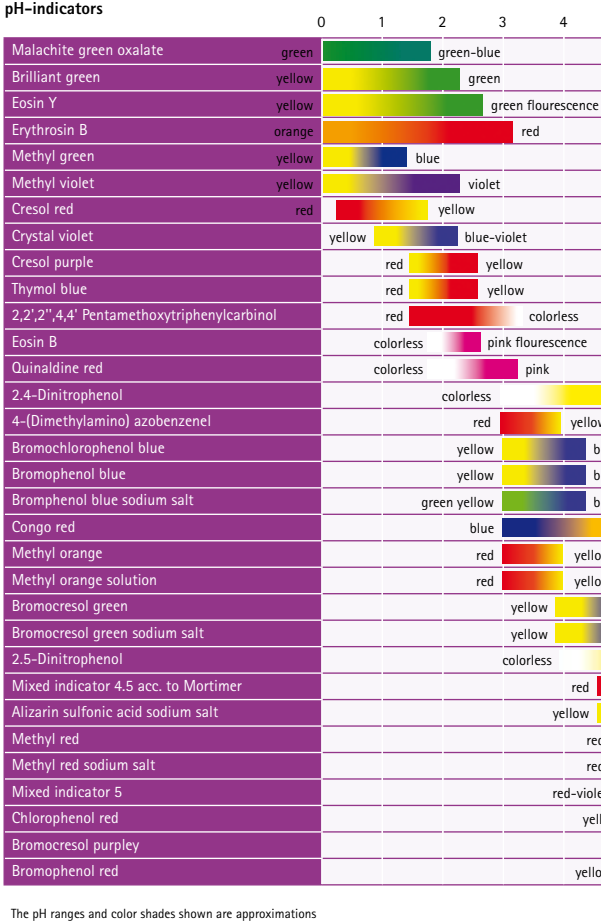
Example

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

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

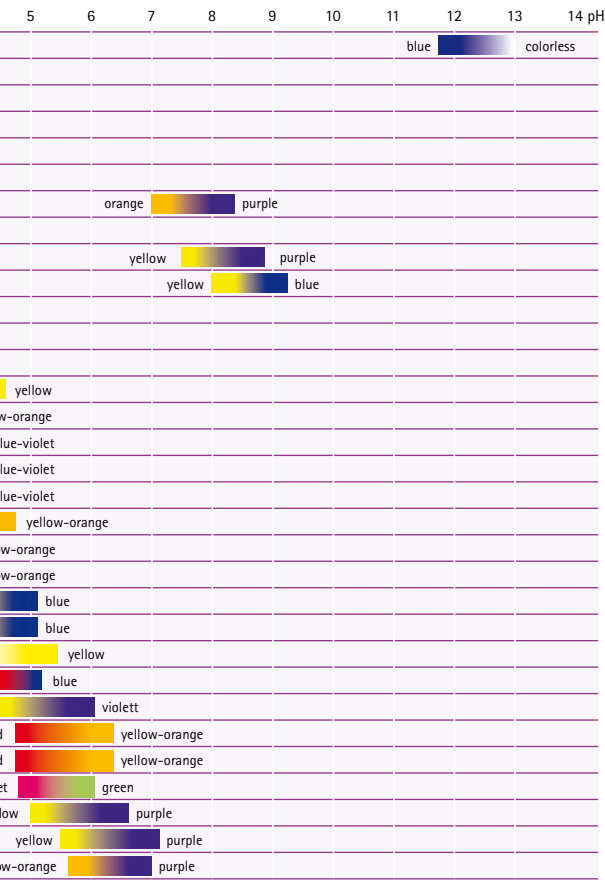
Indicators and buffers

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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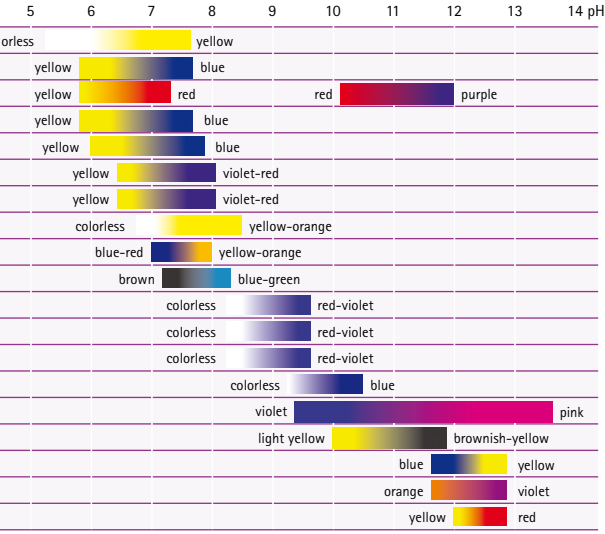
pH-indicators

	0	1	2	3	4	
4-Nitrophenol						col
Bromoxylenol blue						
Alizarin						
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						
Alkali blue						
Alizarin yellow GG						
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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yellow
violet-red
colorless
yellow-orange
blue-red
yellow-orange
brown
blue-green
colorless
red-violet
colorless
red-violet
colorless
red-violet
colorless
blue
violet
pink
light yellow
brownish-yellow
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/[$C_8H_5KO_4$: 20.42 g/l	HCl 0.1 mol/l	50 ml A + x ml B make up to 100 ml*
4	As No. 3	NaOH 0.1 mol/l make up to 100 ml*	50 ml A + x ml B,
5	As No. 2	NaOH 0.1 mol/l	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

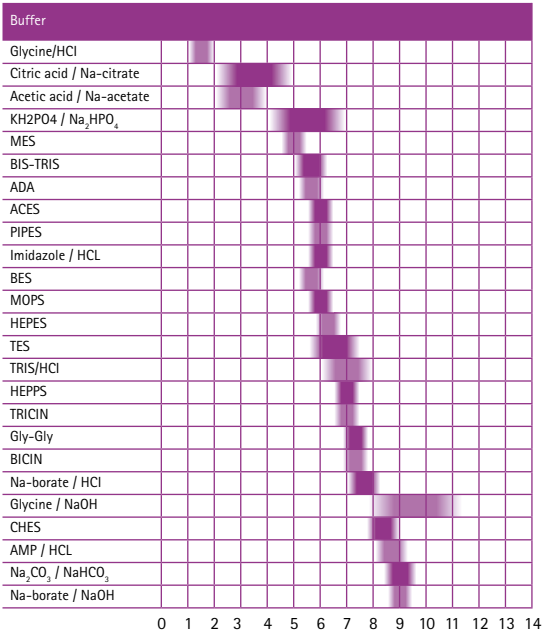
*fill up with dissolution

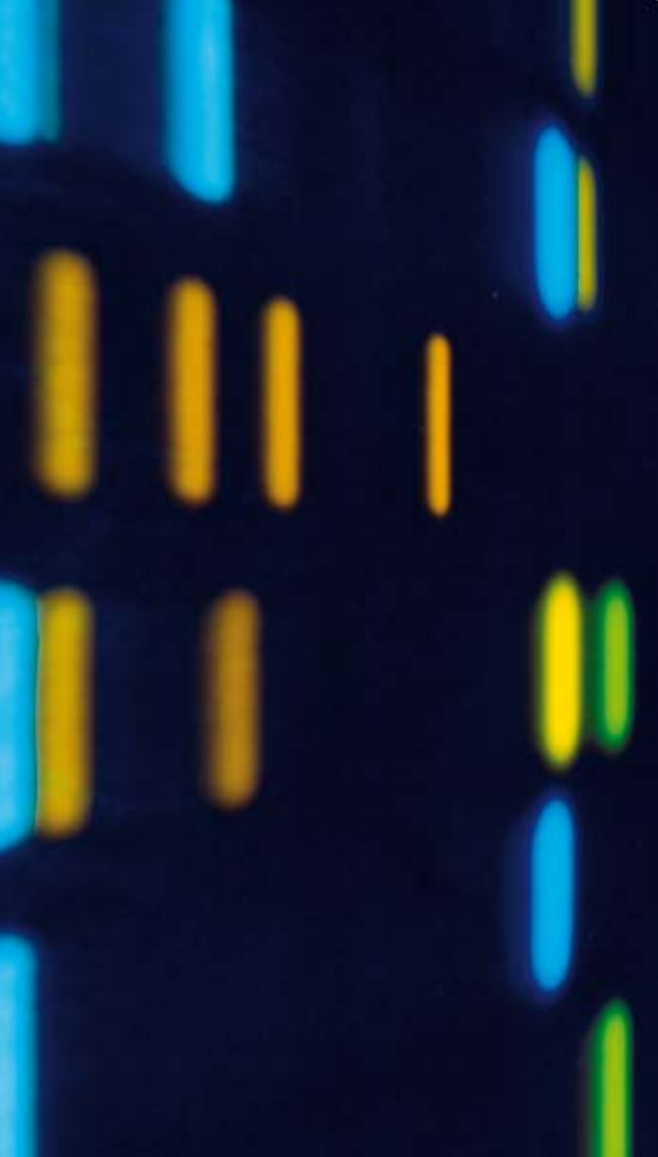
CertiPUR-Buffer Sachets for calibration of pH instruments!

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





Chromatography

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 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.

- **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.

- **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.

- **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 modi-fications 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 (NH2, 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.

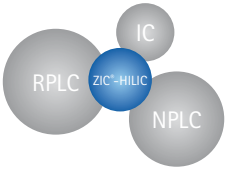


Fig.1
Schematic illustration demonstrating how **ZIC®-HILIC** *complements other areas of chromatography and extends the separation capabilities.*

- **ZIC®-HILIC HPLC** columns are suitable 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.

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

Bild wird in besserer Auflösung benötigt!

Fig.XX
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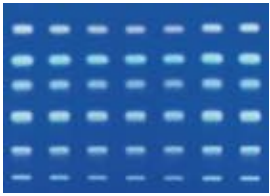

Fig.3
Comparison of the separation of dansyl amino acids on a
(A) *classical TLC silica gel 60 plate or*
(B) *HPTLC silica gel 60 plate under identical conditions. The comparison clearly demonstrates that the HPTLC plate delivers sharper zones with shorter migration distances and hence running times. 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*

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
Aluspher® AL	spherical particles of aluminia oxide	5 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	2 µm

Specifications of column sorbents

Mediaum 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, 7, 10 µm
LiChrosorb® NH_2	irregular particles of silica with γ-Aminopropyl function	5, 7, 10 µm
LiChrosorb® DIOL	spherical particles of silica with DIOL function on carbonchains	5, 7, 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
100 Å		170 m^2/g	
60 Å	0.85 ml/g	700 m^2/g	100 000 N/m
120	1.1	330	50 000
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

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	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	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	2 µm
Chromolith® Rp-18 endcapped	Monolithic high purity silica with octadecyl derivative	2 µm

Pore Size	Pore volume	Spec. surface	% C	Surface coverage	Efficiency
100 Å	1.0 ml/g	300 m^2/g	9.5 %	3.4 $\mu mol/m^2$	55 000 N/m 20 000 N/m
60 Å	0.75 ml/g	300 m^2/g	11.4 %	4.21 $\mu mol/m^2$	55 000 N/m 20 000 N/m
100 Å	1.0 ml/g	300 m^2/g	16.2 %	3.0 $\mu mol/m^2$	55 000 N/m 20 000 N/m
100 Å	1.25 ml/g	350 m^2/g	12.5 %	4.04 $\mu mol/m^2$	55 000 N/m 20 000 N/m
100 Å	1.25 ml/g	350 m^2/g	13.0 %	4.44 $\mu mol/m^2$	55 000 N/m 20 000 N/m
60 Å	0.9 ml/g	360 m^2/g	11.5 %	3.55 $\mu mol/m^2$	55 000 N/m 20 000 N/m
100 Å	1.25 ml/g	350 m^2/g	21.0 %	3.61 $\mu mol/m^2$	55 000 N/m 20 000 N/m
100 Å	1.25 ml/g	350 m^2/g	21.6 %	4.09 $\mu mol/m^2$	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 $\mu mol/m^2$	80 000 N/m
60 Å	1.25 ml/g	350 m^2/g	12.5 %	4.44 $\mu mol/m^2$	100 000 N/m
60 Å	1.25 ml/g	350 m^2/g	13.0 %	3.55 $\mu mol/m^2$	100 000 N/m
60 Å	0.9 ml/g	360 m^2/g	11.5 %	3.61 $\mu mol/m^2$	100 000 N/m
100 Å	1.25 ml/g	350 m^2/g	21.0 %	4.09 $\mu mol/m^2$	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 $\mu mol/m^2$	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: 1000 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

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

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

Bildmaterial wird benötigt!

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 <50mM
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

Sample preparation

Routine laboratory work involves purifying, enriching or separating for subsequent analysis. Solid, liquid and gaseous substances also have to be purified for pro-duction-scale processes. Various chemical and physical methods can be used for this purpose: absorption, adsorption, chroma-tography, distillation, extraction, ion exchange, filtration, complex formation, crystallization, drying and many more. Merck offers a wide range of products with absorptive, adsorptive, filtration and clarification properties. These products can be used for purification but also as reaction and filtration aids, as fillers, additives or as carriers of active ingredients. In addition we offer reagents for the preparation of gases, cooling mixtures or adjusting relative humidity as well as classical laboratory auxiliaries. Products avail-able for Sample preparation are:

- **LiChrolut®** for solid-phase extraction
- **Extrelut® NT** for liquid-liquid extraction
- **LiChrospher® ADS** 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)		Drying agent (1)
				ppm	mg/m³	
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	$CaCl_2$; P2O5; 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)		Drying agent (1)
					ppm	mg/m³	
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

Elutopic 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	0.2	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	4.4	$CHCl_3$	119.38	1.946	61.7
Dichloroethane	113713	3.7	$ClCH_2CH_2Cl$	98.97	1.445	83.4
Dichlormethane	106044	3.4	CH_2Cl_2	84.93	1.424	40.0
1-Butanol	101988	3.9	$CH_3(CH_2)_3OH$	74.12	1.399	117.2
Acetonitrile	100030	6.2	CH_3CN	41.05	1.344	81.6
2--Propanol	101040	4.3	$CH_3CH(OH)CH_3$	60.10	1.378	82.4
Ethyl acetate	100868	4.3	$CH_3COOC_2H_5$	88.10	1.372	77.1
Acetone	100020	5.4	CH_3COCH_3	58.08	1.359	56.2
Ethanol	111727	5.2	C_2H_5OH	46.07	1.361	78.5
1.4-Dioxane	103132	4.8	$C_4H_8O_2$	88.11	1.422	101.0
Tetrahydrofuran	108101	4.2	C_4H_8O	72.11	1.405	66.0
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.

Vapor pressure [mbar] (20°C)	Dynamic viscosity [mPa · s] (22°C)	(40°C)	Surface tension against air or vapor [mN/m] (20°C)	MAC value 1998 mg [ml/m³] 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 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	–	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	9.8	11.0
210	0.56	0.47	27.1	10	4.8	1.01	0.40	9.0	10.5	11.6
87	0.80	0.65	24.2	A(3)	10.6	1.75	0.44	7.6	8.4	8.9
453	0.43	0.36	26.5	100	9.1	1.60	0.42	10.1	11.8	13.2
6.7	2.95	1.78	24.6	100	17.8	1.66	–	–	–	–
97	0.39	–	29.3	40	37.5	3.44	0.65	12.6	14.0	15.4
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	0.58	9.2	10.9	12.1
233	0.32	0.27	23.7	500	20.7	2.70	0.56	12.7	14.7	16.2
59	1.20	0.83	22.8	1000	24.3	1.70	0.88	3.4	3.9	4.2
41	1.21	0.92	33.7	20	2.2	0.40	0.56	5.2	6.0	6.5
200	0.47	0.38	–	50	7.4	1.63	0.57	10.9	11.9	12.6
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 $\triangleq$ 25000 cm^{-1}

Photometry – transmission rate and absorbance

A = - lgT
(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 · m^{-2} (Pa)	bar	atm	kp·m^{-2}	Torr (mm HG)	lbs/sq.in. (psi)
1 N·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·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	Prefix		Symbol
10^{18}	Exa	E	10^{-1}	Deci	d
10^{15}	Peta	P	10^{-2}	Centi	c
10^{12}	Tera	T	10^{-3}	Milli	m
10^{9}	Giga	G	10^{-6}	Micro	µ
10^{6}	Mega	M	10^{-9}	Nano	n
10^{3}	Kilo	k	10^{-12}	Piko	p
10^{2}	Hecto	h	10^{-15}	Femto	f
10	Deca	da	10^{-18}	Atto	a

Concentrations

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

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Basic units

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

Derived units
with conversion of previous units

Size	SI unit Name	Symbol	Further units		Relationship
			Name	Symbol	
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	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

Temperatur

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		

6.220×10^{23} a

$$\frac{1 \text{ mol He}}{\Delta t} = \frac{1}{1} \times$$

$$\frac{(\text{mol Mg})}{\Delta t}$$

H_3O^+ Ra(

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_{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			$J\ mol^{-1}K^{-1}$
Gravitation constant	f	6.672590	·	10^{-11}	$Nm2kg^{-2}$
Intrinsic impedance	Γ	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}	$m3mol^{-1}$
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
Α	α	álpha	a
Β	β	béta	b
Γ	γ	gámma	g
Δ	δ	délta	d
Ε	ε	épsilon	e (short)
Ζ	ζ	zéta	z
Η	η	éta	e (long)
Θ	θ	théta	th
Ι	ι	ióta	i
Κ	κ	káppa	k
Λ	λ	lámbda	l
Μ	μ	mü	m
Ν	ν	nü	n
Ξ	ξ	xi	x
Ο	ο	ómicron	o (short)
Π	π	pi	p
Ρ	ϱ	rho	r
Σ	σ1, ς2	sigma	s
Τ	τ	tau	t
Υ	υ	ýpsilon	y
Φ	φ	phi	ph
Χ	χ	chi	ch
Ψ	ψ	psi	ps
Ω	ω	ómega	o (long)

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

Greek numbers / Roman numbers

1/2	hemi –	
1	mono –	I
1 1/2	sesqui –	
2	di –, bi –	II
2 1/2	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	NN	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.

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

Immediate, residue-free cleaning is prerequisite to reliable work in the lab and production department and is indispensible for producing accurate scientific results. All items of equipment coming into contact with chemical or biological substances must be contaminant-free before and after use.
Merck's high-quality Extran® cleaning agents have provided the solution for more than 25 years now.

The benefits to you:
Extran cleans reliably without leaving any residues, so preventing contaminant carry-over to the next analysis performed. Extran is free from scented materials, colorants, chlorine and toxic ingredients. It therefore produces no unwanted odors and poses no health risk to analysts and operators. Its active ingredients are biodegradable, so environmental demands are also met.

zu viel Text!

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	$3^1/_2$"		5600	$3^1/_2$

NMR: Carbon (13C) chemical shifts

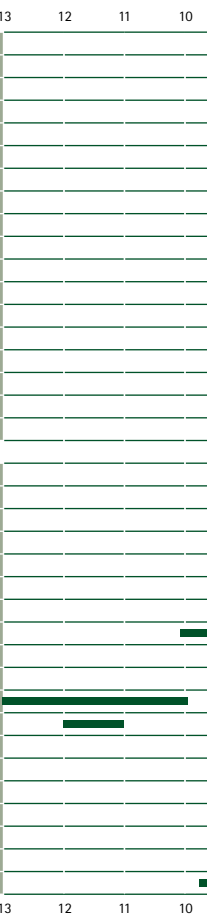
TMS = 0 ppm		220	200	180
$H_3C - C \leqslant$	C primary			
$H_3C -$ Halogen				
$H_3C - O -$				
$H_3C - N <$				
$H_3C - S -$				
$- CH_2 - C \leqslant$	C secondary			
$- CH_2 -$ Halogen				
$- CH_2 - O -$				
$- CH_2 - N <$				
$- CH_2 - S -$				
$> CH - C \leqslant$	C tertiary			
$> CH -$ Halogen				
$> CH - O -$				
$> CH - N <$				
$> CH - S -$				
$\geqslant C - C \leqslant$	C quaternary			
$\geqslant C -$ Halogen				
$\geqslant C - O -$				

		220	200	180
$> C - S \leqslant$				
$\geqslant C - C -$	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			

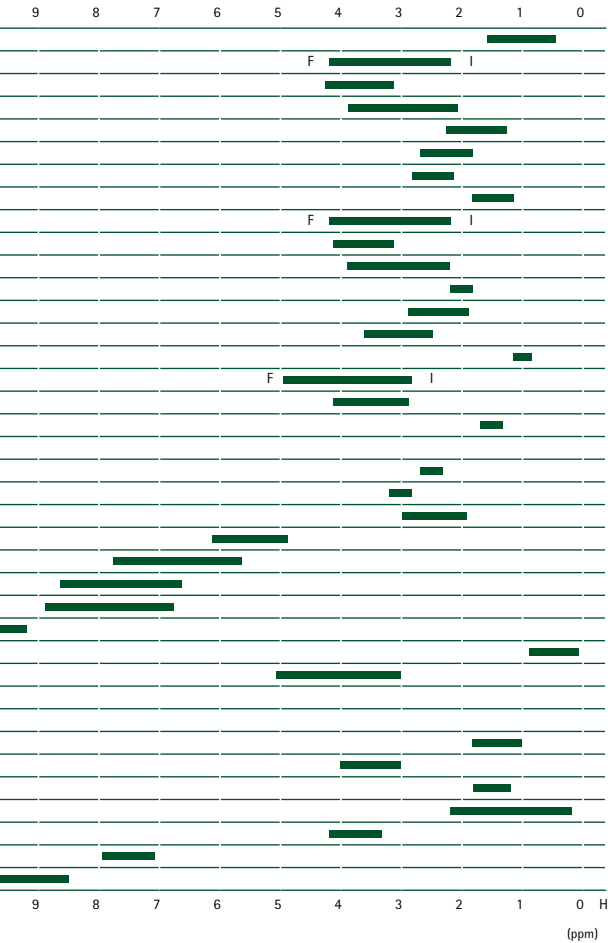

160 140 120 100 80 60 40 20 0 −20 −40
Cl
I
aliphates — cyclopropanes
Cl
I
Cl
I
Cl
I
160 140 120 100 80 60 40 20 0 −20 −40
160 140 120 100 80 60 40 20 0 −20 −40

NMR: Proton chemical shifts

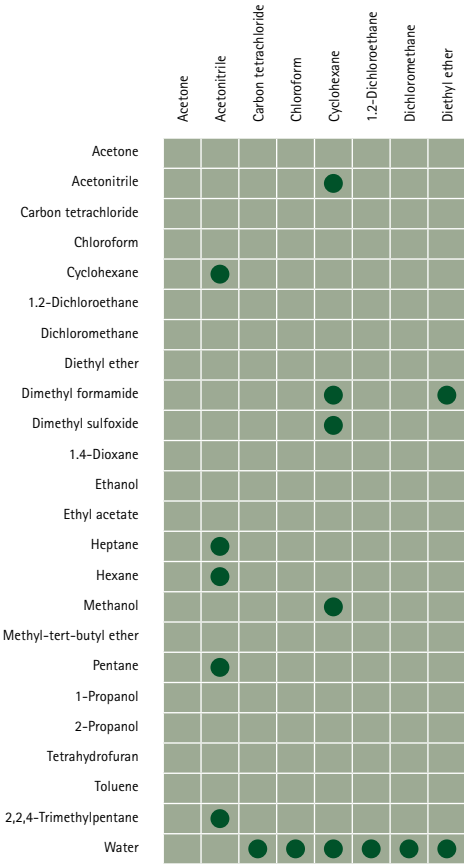
TMS = 0 ppm	
$H_3C - CR_3$	Methyl protons
$H_3C -$ Halogen	
$H_3C - O -$	
$H_3C - N$	
$H_3C \geq C = C <$	
$H_3C \geq C = O$	
$H_3C - Ar$	
$- CH_2 - CR_3$	Methylene protons
$- CH_2 -$ Halogen	
$- CH_2 - O -$	
$- CH_2 - N <$	
$- CH_2 \geq C = C <$	
$- CH_2 \geq C = O$	
$- CH_2 - Ar$	
$\geq CH - CR_3$	Methine protons
$\geq CH -$ Halogen	
$\geq CH - O -$	
$\geq CH - N <$	
$\geq CH \geq C = O$	
$\geq CH - Ar$	
$- C \equiv C - H$	Alkynes
$\geq C \leqslant C - H$	Alkenes, nonconjugated
$\geq C \leqslant C - H$	Alkenes, conjugated
$Ar - H$	Aromatics
$Ar - H$	Heteroaromatics
$O \leqslant C - H$	Aldehydes
ROH*	Alcohols, very dilute solution
ROH*	Alcohols, 0.1–0.9 mol/l
RCO_2H*	Carboxylic acids, dimer
$- SO_3H$	Sulfonic acids
RSH*	Thiols
ArSH*	Thiophenols
RNH_2*	Amines, 0.1–0.9 mol/l
R_2NH*	Amines, 0.1–0.9 mol/l
ArNH-(H, R, Ar)*	Aromatic amines, primary, secondary
RNH_3^+, $R_2NH_2^+$, R_3NH^+	in TFA solution
$ArNH_3^+$, $ArRNH_2^+$, ArR_2NH^+	in TFA solution

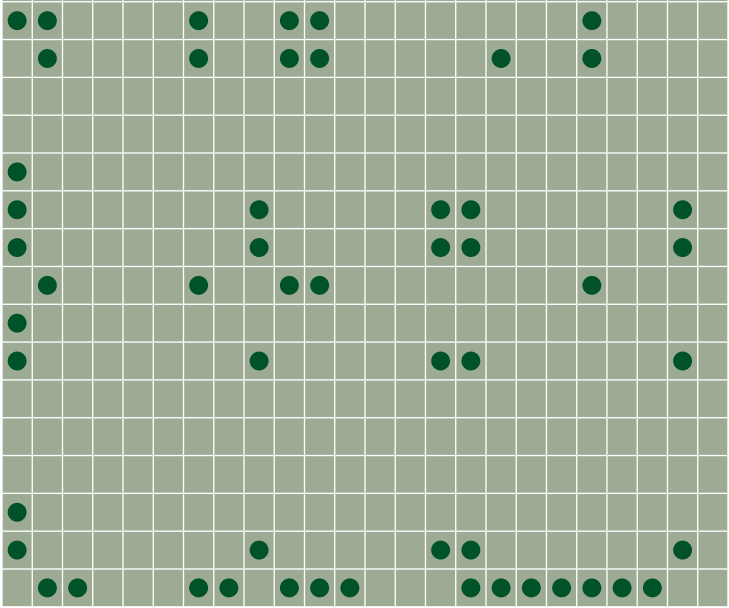


*The chemical shifts of these groups are concentration-dependent and are shifted to lower ppm values in more dilute solutions


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

Stoichiometry formulary

Density

$$\rho = \frac{m}{V}\left[\frac{g}{mL}\right]$$

Substance amount fraction

$$x(x) = \frac{n(x)}{n(x) + n(Lm)} \quad [1]$$

$$x(x) = \frac{n(x)}{n(ges.)} \quad [1]$$

Substance amount concentration

$$c(x) = \frac{n(x)}{V(Lsg)} \quad \left[\frac{mol}{L}\right]$$

$$n(x) = \frac{m(x)}{M(x)} \quad [mol]$$

Substance amount concentration of the equivalent

$$c\ \frac{1}{z}x = \frac{n\ \frac{1}{z}x}{V(Lsg)}\left[\frac{mol}{L}\right]$$

$$n\ \frac{1}{z}x = \frac{m(x)}{M\ \frac{1}{z}x}\left[mol\right]$$

Per cent by weight

$$\omega(x) = \frac{m(x)}{m(Lsg)} \quad [1]$$

Mass per unit volume β

$$\beta = \frac{m(x)}{V(Lsg)} \quad \left[\frac{g}{L}\right]$$

Per cent by volume φ

$$\varphi\ (x) = \frac{V(x)}{V(x) + V(Lm)} \quad [1]$$

Volume concentration σ

$$\sigma\ (x) = \frac{V(x)}{V(Lgs)} \quad [1]$$

Molar volume

$$Vm = \frac{V}{n} \quad \left[\frac{L}{mol}\right]$$

Equation of mixtures

$\omega_1 * m_1 + w_2 * m_2 + ... = \omega_{Mi} * m_{Mi}$

Dilution

$\omega_1 * m_1 = \omega_{Mi} * m_{Mi} \quad m_{Mi} = m_1 + m_2 + ...$

Reconcentration

$\omega_1 * m_1 = \omega_{Mi} * (m_1 - m_2)$

Equation of mixtures for the substance amount of the concentration

$c_1 * V_1 + c_2 * V_2 + ... = c_{Mi} * (V_1 + V_2 + ...)$

Gravimetry

$$\omega(x) = \frac{m(\text{Ausw}) * F * 100 * VF}{m(\text{Einw})} \quad [\%]$$

$$F = \frac{M(\text{ges. Stoff})}{M(\text{ges. Stoff})} \quad [1]$$

$m(x) = m\ (\text{Auswaage}) * F\ [g]$

Volumetry

$$c(x) = \tilde{c}(x) * t(x) \quad \left[\frac{mol}{L}\right]$$

$$t(x) = \frac{c(x)}{\tilde{c}(x)} \quad [1]$$

$n(x) = \tilde{c}(x) * t(x) * V(\text{Lsg}) \quad [mol]$

Recovery calculation

$$\omega(\%\ \text{d.Th.}) = \frac{m(P) * 100}{m(T)} \quad [\%]$$

$m(T) = m(\text{Einw}) * F$

pH-value calculation

$K_W = c(H_3O^+) * c(OH^-) = c2(H_2O)$ $\qquad pH = -lg\ c(H_3O^+)$

$pH = -lg\ \sqrt{K_S * c(acid)}$

$$K_W = 10^{-7}\ \frac{mol}{L} * 10^{-7}\ \frac{mol}{L} = 10^{-14}\left[\frac{mol}{L}\right]^{L^2} \qquad pOH = -lg\ c(OH^-)$$

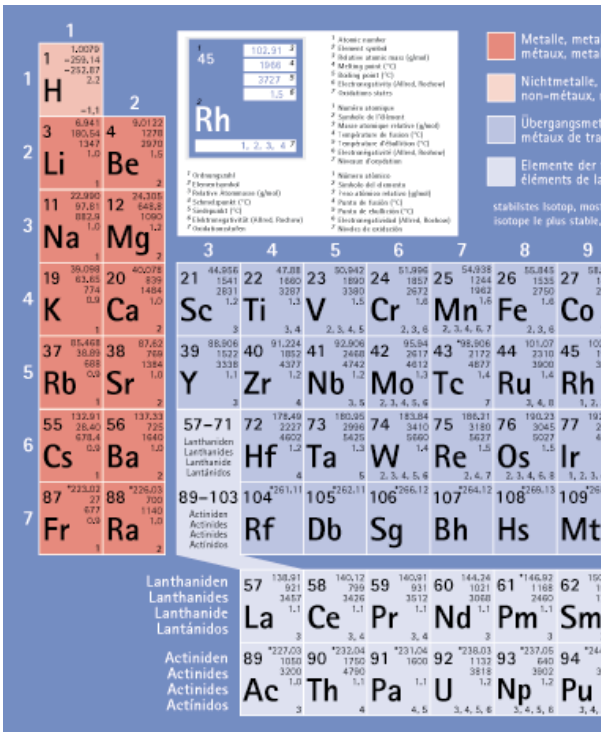
$pOH = -lg\ \sqrt{K_B * c(base)}$

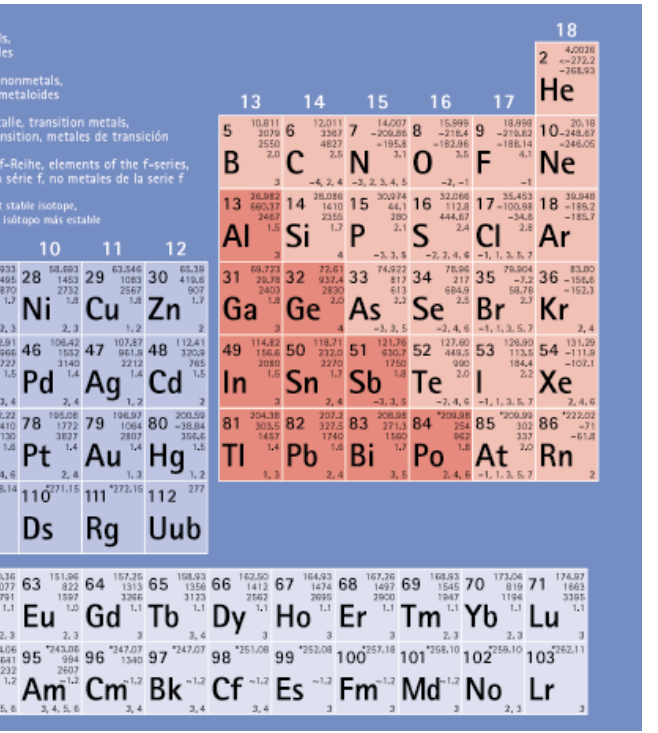
Buffer solution

$$pH = -lg\ (K_S * \frac{c\ (acid)}{c(salt)})$$

Notes

Notes


Rh
45
102.91
1966
3727
1.5
1, 2, 3, 4, 7
Metalle, meta
métaux, meta
Nichtmetalle,
non-métaux,
Übergangsmet
métaux de tra
Elemente der
éléments de la
stabilstes Isotop, mos
isotope le plus stable,
Lanthaniden
Lanthanides
Lanthanide
Lantánidos
Actiniden
Actinides
Actinides
Actínidos


18
2 4,0026 <-272,2 -268,93 He
13 14 15 16 17
5 10,811 2079 2550 2,0 3 B
6 12,011 3367 4827 2,5 -4, 2, 4 C
7 14,007 -209,86 -195,8 3,1 -3, 2, 3, 4, 5 N
8 15,999 -218,4 -182,96 3,5 -2, -1 O
9 18,998 -219,62 -188,14 4,1 -1 F
10 20,18 -248,67 -246,05 Ne
13 26,982 660,37 2467 1,5 3 Al
14 28,086 1410 2355 1,7 4 Si
15 30,974 44,1 280 2,1 3, 5 P
16 32,066 112,8 444,67 2,4 -2, 2, 4, 6 S
17 35,453 -100,98 -34,6 2,8 -1, 1, 3, 5, 7 Cl
18 39,948 -189,2 -185,7 Ar
31 69,723 29,78 2403 1,8 3 Ga
32 72,61 937,4 2830 2,0 4 Ge
33 74,922 817 613 2,2 -3, 3, 5 As
34 78,96 217 684,9 2,5 -2, 4, 6 Se
35 79,904 -7,2 58,78 2,7 -1, 1, 3, 5, 7 Br
36 83,80 -156,6 -152,3 Kr
49 114,82 156,6 2080 1,5 3 In
50 118,71 232,0 2270 1,7 2, 4 Sn
51 121,76 630,7 1750 1,8 -3, 3, 5 Sb
52 127,60 449,5 990 2,0 -2, 4, 6 Te
53 126,90 113,5 184,4 2,2 -1, 1, 3, 5, 7 I
54 131,29 -111,9 -107,1 Xe
81 204,38 303,5 1457 1,4 1, 3 Tl
82 207,2 327,5 1740 1,8 2, 4 Pb
83 208,98 271,3 1560 1,7 3, 5 Bi
84 *209,98 254 962 1,8 2, 4, 6 Po
85 *209,99 302 337 2,0 -1, 1, 3, 5, 7 At
86 *222,02 -71 -61,8 Rn
10 11 12
28 58,693 1453 2732 1,8 2, 3 Ni
29 63,546 1083 2567 1,8 1, 2 Cu
30 65,39 419,6 907 1,7 2 Zn
46 106,42 1552 3140 1,4 2, 4 Pd
47 107,87 961,9 2212 1,4 1 Ag
48 112,41 320,9 765 1,5 2 Cd
78 195,08 1772 3827 1,4 2, 4 Pt
79 196,97 1064 2807 1,4 1, 3 Au
80 200,59 -38,84 356,6 1,5 1, 2 Hg
110 *271,15 Ds
111 *272,15 Rg
112 277 Uub
63 151,96 822 1597 1,0 2, 3 Eu
64 157,25 1313 3266 1,1 3 Gd
65 158,93 1356 3123 1,1 3, 4 Tb
66 162,50 1412 2562 1,1 3 Dy
67 164,93 1474 2695 1,1 3 Ho
68 167,26 1497 2900 1,1 3 Er
69 168,93 1545 1947 1,1 2, 3 Tm
70 173,04 819 1194 1,1 2, 3 Yb
71 174,97 1663 3395 1,1 3 Lu
95 *243,06 994 2607 ~1,2 2, 3, 4, 5, 6 Am
96 *247,07 1340 ~1,2 3, 4 Cm
97 *247,07 ~1,2 3, 4 Bk
98 *251,08 ~1,2 3, 4 Cf
99 *252,08 ~1,2 3 Es
100 *257,18 ~1,2 3 Fm
101 *258,10 ~1,2 3 Md
102 *258,10 2, 3 No
103 *262,11 3 Lr

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