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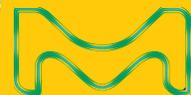
MQuant®

**Compact Laboratory for
Water Testing**

**Kompaktlabor für
Wasseruntersuchungen**

**for the determination of: ammonium, carbonate hardness
(acid-binding capacity), total hardness (and residual hard-
ness), nitrate, nitrite, pH, phosphate, oxygen and oxygen
consumption, temperature**

**zur Bestimmung von: Ammonium, Carbonathärte (SBV),
Gesamthärte (und Resthärte), Nitrat, Nitrit, pH, Phosphat,
Sauerstoff und Sauerstoff-Zehrung, Temperatur**



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* The data given in the auxiliary tables have been taken from the scientific literature and may be subject to changes in accordance with the most recent state of research. In addition, limits may be subject to upward or downward adjustment due to specific environmental conditions or the physiological condition of organisms.



1 Introduction

The MQuant® Compact Laboratory for Water Testing contains all the reagents and auxiliaries necessary for the determination of the parameters of most relevance in connection with the assessment of the quality of water bodies.

The Compact Laboratory is suited for numerous applications, for example for monitoring the quality of waters, for supporting analyses in connection with the biological assessment of waters, and also in the academic and teaching fields.

The tests themselves are based on colorimetric and titrimetric methods. In addition to the instructions for use for the determination of the individual parameters, this brochure contains inter alia a section specifically devoted to sampling, general instructions for performing the analyses, and also detailed data regarding the influence of foreign substances. This supplementary information is also relevant for the determination of the individual parameters. In addition, on the enclosed color cards to be used for the colorimetric tests are provided brief illustrated instructions.

At the end of this brochure, a collection of tables and data is also provided that enables a differentiated assessment of water bodies and the conversion and correction of measurement values.

2 Parameters and number of determinations

Ammonium

50 determinations

Nitrite

200 determinations

Carbonate hardness (ANC)

150 determinations at 12.5 °e (10 °d)

pH

200 determinations

Total hardness

150 determinations at 12.5 °e (10 °d)

Phosphate

100 determinations

Nitrate

100 determinations

Oxygen

100 determinations at 8.5 mg/l O₂

3 Package contents

from MQuant® Ammonium Test, Cat. No. 108024:

- 1 bottle of reagent NH₄-1
- 1 bottle of reagent NH₄-2 (with integrated **blue** microspoon)
- 1 bottle of reagent NH₄-3

from MQuant® Carbonate Hardness Test, cat. No. 108048:

- 1 bottle of reagent CH-1
- 1 bottle of reagent CH-2 (with fitted titration pipette "°d - SBV mmol/l")

from MQuant® Total Hardness Test, Cat. No. 108039:

- 1 bottle of reagent H-1
- 1 bottle of reagent H-2 (with fitted titration pipette "°d - mg/l")

from MQuant® Nitrate Test, Cat. No. 111170:

- 1 bottle of reagent NO₃-1 (with integrated **green** microspoon)

from MQuant® Nitrite Test, Cat. No. 108025:

- 2 bottles of reagent NO₂-1
- 1 bottle of reagent NO₂-2 (with integrated **grey** microspoon)

from MQuant® pH Test, Cat. No. 108027:

- 1 bottle of reagent pH-1

from MQuant® Phosphate Test, Cat. No. 114661:

- 1 bottle of reagent PO₄-1
- 1 bottle of reagent PO₄-2 (with integrated **blue** microspoon)

from MQuant® Oxygen Test, Cat. No. 111107:

- 1 bottle of reagent O₂-1
- 1 bottle of reagent O₂-2
- 2 bottle of reagent O₂-3
- 1 bottle of reagent O₂-4
- 1 bottle of reagent O₂-5 (with fitted titration pipette "mg/l")

- 1 graduated 5-ml plastic syringe
- 3 test vessels with red ring markings
- 1 flat plastic stopper
- 3 test tubes with screw caps
- 1 oxygen reaction bottle (glass bottle with slanted ground-glass stopper and plastic or glass mixing element)
- 1 sliding comparator (black plastic holder to accommodate 2 test tubes)
- 1 color card for ammonium
- 1 color card for nitrate
- 1 color card for nitrite
- 1 color card for pH
- 1 color card for phosphate
- 1 floating thermometer
- 1 sheet of round stickers (for identifying the water samples and the screw caps of the test tubes)

4 Safety and shelf-life

Please observe the safety data sheets and also the warnings on the packaging materials!

Do not eat, drink, or smoke while performing the analyses. Avoid contact of the reagents with your hand; in the event of skin contact, wash off thoroughly under running water.

Store the Compact Laboratory in such a way that it is out of the reach of children and it cannot come into contact with food.

The test reagents are stable up to the date stated on the pack and labels when stored closed at +15 to +25 °C.

5 Principles and definitions

5.1 pH

The degree to which an aqueous solution is acidic or alkaline depends on the respective concentration of the hydrogen ions (H^+) and hydroxide ions (OH^-) resulting from the dissociation of water. This is described by the following formula

$$(\text{concentration } H^+) \times (\text{concentration } OH^-) = 10^{-14} [\text{mol/l}]^2,$$

also referred to as the "ionic product of water". From this formula it follows that the concentration of the H^+ ions or, respectively, of the OH^- ions can vary between 1 ($= 10^0$) mol/l and 10^{-14} mol/l upon the addition of an acid or base. Additionally, this formula is also an expression of the fact that the concentration of either of these ions cannot be altered without affecting that of the other. For the characterization of the acidic or alkaline reaction of an aqueous solution, it is thus sufficient to state the concentration of the H^+ ions. To avoid having to write out the figure awkwardly using decimal potencies, for diluted aqueous solutions it is standard practice to use the negative decimal logarithm of the figure value of the H^+ concentration. This is termed the pH value, or simply the pH.

$$pH = -\lg (\text{concentration } H^+)$$

5 Principles and definitions

5.1 pH

Depending on the respective pH, solutions are referred to as being acidic, neutral, or alkaline (basic):

Solution	pH	H ⁺ concentration in mol/l
acidic	< 7	> 10⁻⁷
strongly acidic	0 - 3	
weakly acidic	3 - 7	
neutral	<7	10⁻⁷ H⁺ concentration = OH⁻ concentration
alkaline (basic)	> 7	< 10⁻⁷
weakly alkaline	7 - 11	
strongly alkaline	11 - 14	

Hydrochloric acid with a concentration of 1 mol/l has a pH of approximately 0, sodium hydroxide solution with a concentration of 1 mol/l a pH of approximately 14, pure water a pH of 7.

5.2 Water hardness

The hardness (total hardness) of a water is due to its content of salts of the alkaline earth metals calcium, magnesium, strontium, and barium (hardening constituents). Since strontium and barium generally occur in waters only in trace amounts, the hardness is defined as the content in a water of calcium ions (Ca²⁺) and magnesium ions (Mg²⁺) in mmol/l. It is, however, conventional practice to set the water hardness in relation only to calcium, i. e. to express also the magnesium portion (generally approximately 15 - 30 % of the total hardness) as calcium concentration.

Officially the water hardness must be expressed in SI units, i. e. in mmol/l Ca²⁺. However, the **German degree (°d)** or **English degree (°e)** is often used as a practical measurement unit; this is defined as follows:

$$1^{\circ}\text{d} = 10 \text{ mg/l CaO} = 17.85 \text{ mg/l CaCO}_3 = 1.25^{\circ}\text{e}$$

Since the molar mass of CaO is 56 mg/mmol, 10 mg CaO is equivalent to 10/56 = 0.178 mmol Ca²⁺, and the relation is thus

$$1^{\circ}\text{d} = 0.178 \text{ mmol/l Ca}^{2+}$$

$$1^{\circ}\text{e} = 0.142 \text{ mmol/l Ca}^{2+}$$

or

$$1 \text{ mmol/l Ca}^{2+} = 5.6^{\circ}\text{d} = 7.0^{\circ}\text{e}$$

Any hardness remaining after water-softening procedures is referred to as **residual hardness**.



5 Principles and definitions

5.2 Water hardness

Assessment of the water	Water hardness			
	in °d	in °e	in mmol/l (Ca + Mg)	in mg/l CaCO ₃
soft	< 8.4	< 10.5	< 1.5	< 150
moderately hard	8.4 - 14	10.5 - 17.5	1.5 - 2.5	150 - 250
hard	> 14	> 17.5	> 2.5	> 250

5.3 Carbonate hardness

The carbonate hardness is that proportion of all those **hardness ions** Ca²⁺ and Mg²⁺ present in one litre of water for which there is an equivalent quantity of hydrogen carbonate ions (HCO₃⁻) and carbonate ions (CO₃²⁻), which originate from dissolved carbonic acid. When the water boils for a relatively long time, except for a small amount, the hydrogen carbonates and carbonates of the hardening constituents are precipitated as insoluble carbonates. For this reason, the carbonate hardness was formerly also referred to as **temporary hardness** (in contrast to **permanent hardness**, which is caused by the sulfates and chlorides of the hardening constituents).

The carbonate hardness is - like the total hardness - usually expressed in mmol/l Ca²⁺, in °d or, respectively, in °e.

Since the hydrogen carbonate and carbonate ions present in a water are capable of binding acid (i. e. H⁺ ions), the carbonate hardness can also be expressed as the **acid-binding capacity (ANC)**. This is understood as that quantity of hydrochloric acid (0.1 mol/l) that is required to titrate 100 ml of water to a pH of 4.3. The acid-binding capacity of a given water sample, which is set in relation to the ions of carbonic acid, is exhausted at this pH, i. e. all hydrogen carbonate and carbonate ions have taken up H⁺ ions, with the result that only dissolved carbonic acid is still present. (This is why the German DIN 38409-H7 standard recommends the term **acid capacity to pH 4.3**.)

Since the acid-binding capacity is determined by means of titration with hydrochloric acid (addition of monovalent H⁺ ions), but on the other hand the carbonate hardness is defined as the concentration of bivalent hardness ions, the following formula applies:

$$\text{ANC [mmol/l]} / 2 = \text{carbonate hardness [mmol/l Ca}^{2+}]$$

5 Principles and definitions

5.3 Carbonate hardness

Using the formula stated in the section "Water hardness"

$$1 \text{ mmol/l Ca}^{2+} = 5.6 \text{ °d} = 7.0 \text{ °e}$$

it follows that

$$\text{ANC [mmol/l]} / 2 = \text{carbonate hardness [mmol/l Ca}^{2+}] = \text{carbonate hardness [°d]} / 5.6 = \text{carbonate hardness [°e]} / 7.0$$

or

$$\text{ANC [mmol/l]} \times 2.8 = \text{carbonate hardness [°d]} = \text{carbonate hardness [mmol/l Ca}^{2+}] \times 5.6$$

and

$$\text{ANC [mmol/l]} \times 3.5 = \text{carbonate hardness [°e]} = \text{carbonate hardness [mmol/l Ca}^{2+}] \times 7.0$$

The total hardness should also always be determined along with the carbonate hardness. This is because some water samples contain hydrogen carbonates and carbonates other than those of calcium and magnesium, meaning that under certain circumstances more hydrogen carbonate and carbonate ions may be present than the quantity equivalent to the hardness ions. Thus, the value found for the carbonate hardness may be higher than that found for the total hardness. In this case, for the carbonate hardness the value determined for the total hardness must be stated.

5.4 Oxygen consumption / biochemical oxygen demand (BOD)

The reduction of the oxygen content of a water caused by oxygen-consuming chemical and biochemical processes is generally referred to as **oxygen consumption**. When the oxygen depletion is due to microorganisms and the measurement is performed under defined conditions, this process is also referred to as **biochemical oxygen demand** or **BOD**. The BOD is defined as that amount of oxygen that is consumed by microorganisms in n days to oxidatively degrade the organic substances present in one litre of water at a temperature of 20 °C. The BOD provides a point of reference for the assessment of a water regarding its load with biologically oxidizable organic substances and its biological activity.

The reason why the BOD is not determined until after one or more days is because biological processes take considerably more time than chemical processes. In most cases organic substances have been biologically degraded to a degree of approximately 70% after five days (n = 5). Therefore, the BOD is generally determined after this period of time (BOD₅).

6 Methods and measuring ranges / graduations

Method	Method	Measuring range / graduation
Ammonium	Ammonium reacts with a chlorinating agent to form monochloramine, which in turn reacts with thymol to form green 2,2'-isopropyl-5,5' methyl indophenol. This is then determined colorimetrically.	0 - 0.2 - 0.4 - 0.6 - 1 - 2 -3 - 5 mg/l NH₄⁺
Carbonate hardness	acid-binding capacity (ANC)	The water sample is titrated with hydrochloric acid (to pH 4.3), with an indicator changing from blue to red. All hydrogen carbonate and carbonate ions present in the water sample are measured in this titration or, respectively, the quantities of calcium and magnesium ions equivalent to these ions. Measuring range with 1 full pipette: 0.2 - 20 °d 0.25 - 25 °e (ANC 0.1 - 7.2 mmol/l) Graduation of the titration pipette: 1 deviation = 0.2 °d (0.1 mmol/l, 0.25 °e)
Total hardness	Calcium and magnesium ions react with an indicator to form a red complex. Upon titration with Titriplex® III (ethylenedinitrilotetraacetic acid, disodium salt) the indicator is released from this complex, with a change in color to green.	Measuring range with 1 full pipette: 0.2 - 20 °d 0.25 - 25 °e (10 - 360 mg/l CaCO ₃) Graduation of the titration pipette: 1 deviation = 0.2 °d (10 mg/l, 0.25 °e)
Nitrate	NO ₃ ⁻	Nitrate becomes reduced to nitrite, which reacts with sulfanilic acid to form a diazonium salt. This in turn reacts with 2,5-dihydroxybenzoic acid to form an orange-yellow azo dye, which is then determined colorimetrically.
Nitrite	NO ₂ ⁻	Nitrite reacts with sulfanilic acid to form a diazonium salt, which in turn reacts with N-(1-naphthyl)ethylenediamine dihydrochloride to form a red-violet azo dye. This is then determined colorimetrically.



6 Methods and measuring ranges / graduations

	Method	Measuring range / graduation
pH	An indicator added to the water sample assumes a color dependent on the pH; this color is then determined colorimetrically.	4.5 - 5.0 - 5.5 - 6.0 - 6.5 - 7.0 - 7.5 - 8.0 - 8.5 - 9.0
Phosphate	PO_4^{3-} (orthophosphate) Orthophosphate ions react with molybdate ions to form molybdato-phosphoric acid. This is in turn reduced to phosphomolybdenum blue (PMB), which is then determined colorimetrically.	0 - 0.25 - 0.50 - 0.75 - 1.0 - 1.5 - 2.0 - 3.0 mg/l PO_4^{3-}
Oxygen	O_2 Oxygen oxidizes bivalent manganese to higher-valence manganese hydroxides. In the subsequent reduction with iodide to Mn(II), a quantity of iodine equivalent to the dissolved oxygen is formed, with the solution changing to violet to blue in color - depending on the oxygen content - in the presence of starch as indicator. The iodine is then titrated with sodium thiosulfate until decoloration of the solution.	Measuring range with 1 full pipette: 0.1 - 10 mg/l O_2 Graduation of the titration pipette: 1 division = 0.1 mg/l O_2



7 Sampling

In the case of surface waters, water samples should be taken from different places and from different depths, which are both to be recorded in a sampling protocol. Additionally the weather conditions and other special observations should also be recorded in the protocol.

In cases in which it is suspected that wastewater is being discharged, then a minimum of three samples should be taken, namely

- a) from the suspected source of discharge;
- b) from the polluted water downstream of the suspected point of discharge; and
- c) from a nonpolluted section of water, wherever possible upstream from the suspect point of discharge.

When investigating ponds and pools, samples should be taken for measurement at least at the inflow and the outflow.

Clean, tightly closing glass or plastic bottles are suitable for the collection of water samples.

It is advisable to take the individual samples at a water depth of 20 to 50 cm. Prior to taking the actual samples, the sample bottles must be thoroughly rinsed with the water to be tested. The bottles are subsequently filled and closed while submerged in the water, taking care to avoid trapping air bubbles in the bottles.

Depending on the composition of the water sample, the concentrations of the substances contained can change within a very short space of time as a result of physical, chemical, or biological processes. For this reason the samples should be analyzed as soon as possible after they have been taken. For short-term storage the samples should be kept in a cool (2 - 5 °C) and dark place.

8 General description of methods

Titrimetric method

First an indicator is added to the sample. Then a reagent solution of defined concentration (**titration solution**) is added dropwise, to react with the substance to be determined. Once the entire quantity of the substance in question present in the measurement sample has reacted (**endpoint of the titration**), the indicator changes color (**color change**). The volume of titration solution required to bring about this change in color is proportional to the content of the substance in question in the measurement sample. Therefore, in the tests using a titration pipette, the content to be determined can be directly read off from the graduation scale on the pipette.

8 General description of methods

Colorimetric method

In this method reagents are added to the water sample that undergo a color reaction with the respective substance to be determined. The intensity of the color formed in this process is proportional to the content of the substance in question. This is why the color of the measurement solution is then compared with the color fields of a color card, each of which corresponds to a specific concentration. For this purpose, the open test vessel containing the measurement sample is moved along the row of color fields, reading off the concentration given for the field that best matches the sample when viewed from above (**color match**).

In the MQuant® Compact Laboratory for Water Testing, with the exception of the phosphate determination two test vessels are used for each color match. These vessels are inserted into a so-called **sliding comparator**; one vessel contains the measurement sample, the second the blank (water sample without reagents). The comparator is then moved along the color card until the best possible color match is achieved when the open test vessels are viewed from above. By means of the blank, any slight turbidities and intrinsic colorations of the water sample are automatically compensated for.

9 General instructions for performing the analyses

- Prior to their use, the test vessels or test tubes must be rinsed several times with the water to be tested.
- In connection with the ammonium, nitrate, nitrite, and phosphate tests, if the concentration of the substance in question is above the respective measuring range, then the water sample must be diluted with distilled or deionized water before the analysis. The concentration of the diluted solution should ideally be approximately in the middle of the measuring range. The measurement result must subsequently be multiplied by the dilution factor.
- The dropping bottles must be held vertically while adding the reagents. The drops must be added slowly (approx. 1 drop per second).
- The microspoons integrated into the screw caps of the reagent bottles must be used only for withdrawing and adding the respective reagents. Do not allow the microspoons to come into contact with other reagents or sample materials.
- Each reagent bottle must be closed with the respective screw cap immediately after withdrawal of the reagent. The enclosed stickers can be used to mark the screw caps to avoid confusion.
- The reagent bottles containing titration solutions in this Compact Laboratory already have the titration pipettes fitted. In the refill packs containing a titration pipette, the pipette is positioned alongside the reagent bottles and must be loosely attached to the bottle of titration solution in order to draw up the syringe.



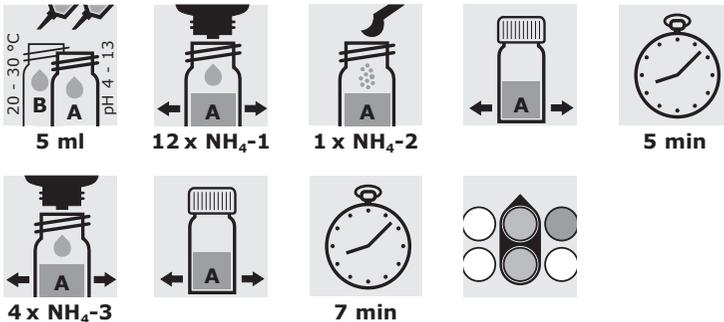
9 General instructions for performing the analyses

- While filling the titration pipettes care must be taken that no air enters the dropping tube. If this happens, return the titration solution to the reagent bottle and repeat the process.
- The scales on the titration pipettes are specific to the respective parameters. Care must therefore be taken not to confuse the titration pipettes.
- When performing titrimetric measurements, it is only the consumption of the titration solution that is dependent on the concentration of the substance to be determined, but not the consumption of the respective indicator solution. This is why there is usually a remainder of one of the solutions when the other has been fully used up.
- If the titration pipette is filled more than once, higher values than 1 pipette filling can be measured.
- For the colorimetric tests, in addition to the detailed instructions for use brief illustrated versions are provided on the respective color cards.

10 Instructions for the determination of the individual parameters

10.1 Ammonium

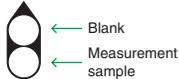
Procedure:



10 Instructions for the determination of the individual parameters

en 10.1 Ammonium

Procedure:

Rinse two test tubes with screw caps several times with the pretreated sample.			
	Measurement sample	Blank	
Pretreated sample (20 - 30 °C)	5 ml	5 ml	Inject into the test tube with the syringe.
Reagent NH ₄ -1	12 drops ¹⁾	-	Add, close the tube, and mix.
Reagent NH ₄ -2	1 level blue microspoon (in the cap of the NH ₄ -2 bottle)	-	Add, close the tube, and shake vigorously until the reagent is completely dissolved .
Leave to stand for 5 min.			
Reagent NH ₄ -3	4 drops ¹⁾	-	Add, close the tube, and mix.
Insert the test tubes into the sliding comparator as shown in the diagram and place the comparator on the color card as indicated by the latter.			
Leave to stand for 7 min.			
Slide the comparator along the color scale until the closest possible color match is achieved between the two open tubes when viewed above. Read off the result in mg/l NH ₄ ⁺ or NH ₄ -N from the color card indicated by the pointed end of the sliding comparator.			

¹⁾ **Hold the bottle vertically while adding the reagent!**

Notes:

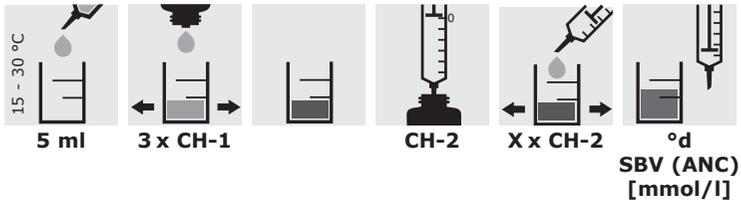
- Analyze samples immediately after sampling.
- Filter turbid water samples prior to the determination.
- Since ammonium ions are in a pH-dependent equilibrium with dissolved free ammonia (NH₃), also the latter is measured in the form of ammonium ions in this determination. Thus this test always measures the “total ammonium concentration”.



10 Instructions for the determination of the individual parameters

10.2 Carbonate hardness

Procedure:



Rinse the test vessel with the red ring markings several times with the pre-treated sample.		
Pre-treated sample (15 - 30 °C)	5 ml	Inject into the test vessel with the syringe.
Reagent CH-1	3 drops ¹⁾	Add and swirl. The solution must turn blue in color. Otherwise no carbonate hardness can be determined.
<p>Place the titration pipette loosely on the open reagent bottle CH-2. Slowly withdraw the piston of the titration pipette from the lowest position until the lower edge of the black piston seal is level with the zero mark of the scale. (This fills only the dropping tube with titration solution.)</p> <p>Remove the titration pipette and briefly wipe the tip of the dropping tube. Then slowly add the titration solution dropwise to the sample while swirling until its color changes from blue via grey (shortly before the complete color change) to red. Shortly before the color changes, wait a few seconds after adding each drop.</p> <p>Read off the result in °d or - as SBV (ANC, $K_{S4.3}$) - in mmol/l from the corresponding scale of the titration pipette at the lower edge of the black piston seal.</p>		

¹⁾ Hold the bottle vertically while adding the reagent!

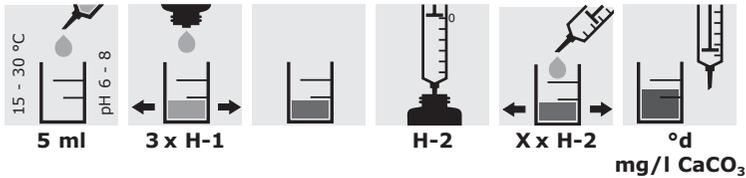
Notes:

- **The total hardness should also always be determined along with the carbonate hardness.**
If the value found for the carbonate hardness is higher than the value found for the total hardness, the latter must be taken also as the result for the carbonate hardness (see section 6 "Principles and definitions").
- While filling the titration pipette, it must **not** be screwed tightly on the reagent bottle!
- After the analysis inject any titration solution still remaining in the pipette back into the reagent bottle CH-2 and **close the reagent bottle tightly using the pipette instead of the screw cap.**

10 Instructions for the determination of the individual parameters

en 10.3 Total hardness

Procedure:



Rinse a test vessel with the red ring markings several times with the pretreated sample.		
Pretreated sample (15 - 30 °C)	5 ml	Inject into the test vessel with the syringe.
Reagent H-1	3 drops ¹⁾	Add and swirl. The sample turns red in the presence of hardening constituents.
Place the titration pipette loosely on the open reagent bottle H-2. Slowly withdraw the piston of the titration pipette from the lowest position until the lower edge of the black piston seal is level with the zero mark of the scale. (This fills only the dropping tube with titration solution.)		
Remove the titration pipette and briefly wipe the tip of the dropping tube. Then slowly add the titration solution dropwise to the sample while swirling until its color changes from red via grey-violet (shortly before the complete color change) to green . Shortly before the color changes, wait a few seconds after adding each drop.		
Read off the result in °d or mg/l CaCO ₃ from the corresponding scale of the titration pipette at the lower edge of the black piston seal.		

¹⁾ **Hold the bottle vertically while adding the reagent!**

Notes:

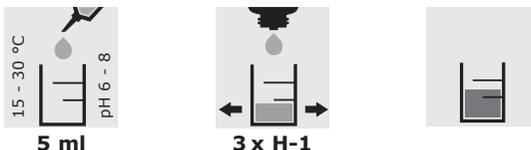
- The pH of the water sample should be within the range 6 - 8. Adjust, if necessary, with sodium hydroxide solution or hydrochloric acid.
- While filling the titration pipette, it must **not** be screwed tightly on the reagent bottle!
- After the analysis inject any titration solution still remaining in the pipette back into the reagent bottle H-2 and **close the reagent bottle tightly using the pipette instead of the screw cap.**

10 Instructions for the determination of the individual parameters



10.4 Residual hardness

Procedure:



Rinse a test vessel with the red ring markings several times with the pretreated sample.		
Pretreated sample (15 - 30 °C)	5 ml	Inject into the test vessel with the syringe.
Reagent H-1	3 drops ¹⁾	Add and swirl. The sample turns red in color in the presence of hardening constituents.

¹⁾ **Hold the bottle vertically while adding the reagent!**

Evaluation:

Depending on the residual hardness present, the color of the reaction solution changes as follows:

green:	0 °d (0 °e), i. e. no residual hardness
grey-violet:	0.1 °d (0.1 °e)
red-violet:	0.5 °d (0.6 °e)
red:	over 0.5 °d (0.6 °e)

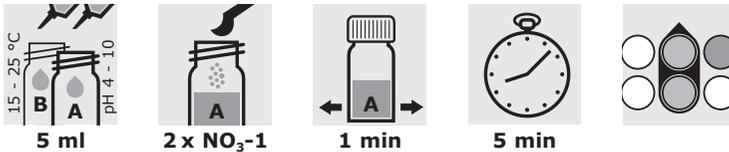
Note:

- The pH of the water sample should be within the range 6 - 8. Adjust, if necessary, with sodium hydroxide solution or hydrochloric acid.

10 Instructions for the determination of the individual parameters

en 10.5 Nitrate

Procedure:



Rinse two test tubes with screw caps several times with the pretreated sample.			
	Measurement sample	Blank	
Pretreated sample (15 - 25 °C) Reagent NO ₃ -1	5 ml 2 level green microspoons (in the cap of the NO ₃ -1 bottle)	5 ml -	Inject into the test tube with the syringe. Add, close the tube tightly, and shake vigorously for 1 min.
Insert the test tubes into the sliding comparator as shown in the diagram and place the comparator on the color card as indicated by the latter.			
Leave to stand for 5 min.			
Slide the comparator along the color scale until the closest possible color match is achieved between the two open tubes when viewed above. Read off the result in mg/l NO ₃ ⁻ or NO ₃ -N from the color card indicated by the pointed end of the sliding comparator.			

Notes:

- Filter turbid water samples prior to the determination.
- Any black residues occurring in the measurement sample are due to the reaction mechanism and have no effect on the measurement result.
- In determining nitrate, nitrite concentrations exceeding 0.5 mg/l are also detected (see "Influence of foreign substances"). The resultant error can be corrected approximately by calculation as follows:

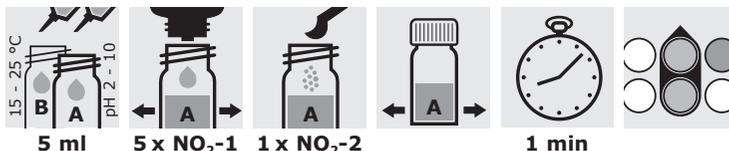
$$\text{Actual nitrate content} = \text{result for nitrate} - 1.35 \times \text{result for nitrite}$$



10 Instructions for the determination of the individual parameters

10.6 Nitrite

Procedure:



Rinse two test tubes with screw caps several times with the pretreated sample.			
	Measurement sample	Blank	
Pretreated sample (15 - 25 °C)	5 ml	5 ml	Inject into the test tube with the syringe. Add, close the tube, and mix. Add, close the tube, and shake vigorously until the reagent is completely dissolved.
Reagent NO ₂ -1	5 drops ¹⁾	-	
Reagent NO ₂ -2	1 level grey microspoon (in the cap of the NO ₂ -2 bottles)	-	
Insert the test tubes into the sliding comparator as shown in the diagram and place the comparator on the color card as indicated by the latter.			
Leave to stand for 1 min.			
Slide the comparator along the color scale until the closest possible color match is achieved between the two open tubes when viewed above. Read off the result in mg/l NO ₂ ⁻ or NO ₂ -N from the color card indicated by the pointed end of the sliding comparator.			

¹⁾ Hold the bottle vertically while adding the reagent!

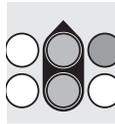
Notes:

- Analyze samples immediately after sampling.
- Filter turbid water samples prior to the determination. (For filtration use glass-fibre paper or a membrane filter washed with hot water.)

10 Instructions for the determination of the individual parameters

en 10.7 pH

Procedure:



Rinse two test tubes with screw caps several times with the pretreated sample.

	Measurement sample	Blank	
Pretreated sample (15 - 25 °C)	5 ml	5 ml	Inject into the test tube with the syringe. Add, close the tube, and mix.
Reagent pH-1	2 drops ¹⁾	-	

Insert the test tubes into the sliding comparator as shown in the diagram and place the comparator on the color card as indicated by the latter.

Blank
Measurement sample

Slide the comparator along the color scale until the closest possible color match is achieved between the two open tubes when viewed above.

Read off the pH from the color card indicated by the pointed end of the sliding comparator.

¹⁾ Hold the bottle vertically while adding the reagent!

Notes:

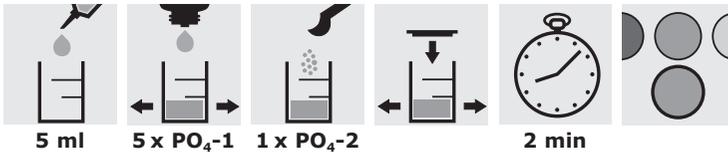
- To distinctly recognize the color tone of the indicator, the samples should be colorless and clear, or only faintly colored and slightly turbid.
- After the determination, rinse the test tubes using distilled water only.



10 Instructions for the determination of the individual parameters

10.8 Phosphate

Procedure:



Rinse a test vessel with the red ring markings several times with the pretreated sample.		
Pretreated sample	5 ml	Inject into the test vessel with the syringe. Add and swirl. Add, close the vessel and shake vigorously until the reagent is completely dissolved.
Reagent PO ₄ -1	5 drops ¹⁾	
Reagent PO ₄ -2	1 level blue microspoon (in the cap of the PO ₄ -2 bottle)	
Leave to stand for 2 min.		
Place the test vessel on the white area next to the color fields of the color card and determine with which field the color of the measurement solution, when viewed from above, coincides most exactly. Read off the result in PO ₄ ³⁻ from the color card.		

¹⁾ **Hold the bottle vertically while adding the reagent!**

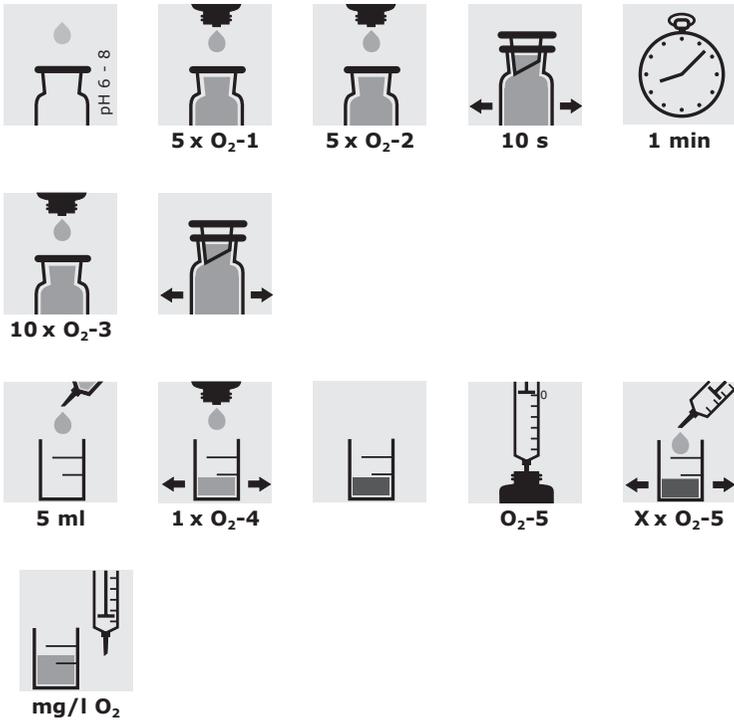
Notes:

- The pH of the water sample should be within the range 5 - 8. Adjust, if necessary, with sodium hydroxide solution or sulfuric acid.
- Filter turbid water samples prior to the determination.
- After the determination, rinse the test vessel with distilled water. **Do not use any phosphate-containing detergents.**

10 Instructions for the determination of the individual parameters

en 10.9 Oxygen

Procedure:





10 Instructions for the determination of the individual parameters

10.9 Oxygen

Procedure:

Rinse the oxygen reaction bottle several times with the pretreated sample, taking care that the mixing element does not fall out.		
Pretreated sample		Fill bubble-free into the oxygen reaction bottle to overflowing .
Reagent O ₂ -1	5 drops ¹⁾	Add.
Reagent O ₂ -2	5 drops ¹⁾	Add, close the bottle bubble-free with the ground-glass stopper, and mix for 10 sec.
Leave the closed oxygen reaction bottle to stand for 1 min at constant temperature. (A precipitate may be formed.)		
Reagent O ₂ -3	10 drops ^{1), 2)}	Add, close the bottle bubble-free with the ground-glass stopper, and mix thoroughly: sample-reagent mixture
Rinse the test vessel several times with the sample-reagent mixture .		
Sample-reagent mixture	5 ml	Inject into the test vessel with the syringe.
Reagenz O ₂ -4	1 drop ¹⁾	Add and swirl. Depending on the oxygen content, the solution turns violet to blue in color.
Place the titration pipette loosely on the open reagent bottle O ₂ -5. Slowly withdraw the piston of the titration pipette from its lowest position until the lower edge of the black piston seal is level with the zero mark of the scale. (This fills only the dropping tube with the titration solution.) Remove the titration pipette and briefly wipe the tip of the dropping tube. Then slowly add the titration solution dropwise to the sample while swirling until the sample becomes entirely colorless . Shortly before the color changes, wait a few seconds after adding each drop. Read off the result in mg/l from the scale of the titration pipette at the lower edge of the black piston seal.		

¹⁾ **Hold the bottle vertically while adding the reagent!**

²⁾ In the case of very high oxygen concentrations, an additional 1 - 3 drops of reagent O₂-3 must be added to ensure the complete dissolution of the precipitate.

10 Instructions for the determination of the individual parameters

en 10.9 Oxygen

Notes:

- Analyze samples immediately after sampling. If this is not possible, immediately perform steps 1 and 2 to fix the oxygen contained in the sample. The closed reaction bottle, which must be free of air bubbles, can then be stored for a maximum of 24 hours, instead of 1 min as stated in step 2 (in a cool place protected from light).
- Some liquid overflows while adding reagents 1 and 2 and while inserting the ground-glass stopper. The glass bottle should therefore be placed, if necessary, in a bowl or on an insensitive surface (e. g. filter paper).
- Should a blue coloration of the solution recur after the titration has been completed, this must not be taken into account.
- While filling the titration pipette, it must **not** be screwed tightly on the reagent bottle!
- After the analysis inject any titration solution still remaining in the pipette back into the reagent bottle O₂-5 and **close the reagent bottle tightly using the pipette instead of the screw cap.**

10 Instructions for the determination of the individual parameters

10.10 Oxygen consumption

Procedure:

1. Determine the oxygen content **immediately** after sampling and - if necessary - aeration of the sample (see section 10.9 "Oxygen"):
result 1.
2. Rinse the oxygen reaction bottle several times with sample water or, respectively, with aerated sample water. Then fill bubble-free to overflowing as in step 1, **but this time do not add any reagents**. Close the bottle and store for n days in the dark at 20 °C. (In most cases 5 days are appropriate; see section 6 "Principles and definitions".) Subsequently determine the oxygen content anew (see section 10.9 "Oxygen"):
result 2.

Evaluation:

Oxygen consumption in mg/l O₂ = result 1 - result 2

Notes:

- In the case of a low oxygen content and a high oxygen consumption (high organic load), the samples must be aerated at 20 °C prior to the determination (e.g. by stirring with a glass rod). Enrichment with oxygen is essential if – for the unaerated sample – **result 2** is lower than 2 mg/l O₂.
- Samples containing higher organisms (zooplankton) yield false-high oxygen consumption values.

10 Instructions for the determination of the individual parameters

en 10.11 Temperature

Procedure:

Immerse or float thermometer until the displayed temperature does not change.

11 Influence of foreign substances

The individual determinations are not yet interfered with up to the concentrations of foreign substances given in the following tables.

The influence of surfactants was tested using the following substances:

Cationic surfactants:

N-cetylpyridinium chloride

Anionic surfactants:

Na-dodecyl sulfate

Hydrogen peroxide was used as oxidizing agent.

Seawater and brackish water were prepared in the following densities using natural sea salt:

Seawater 1.024 g/ml

Brackish water 1.015 g/ml

Water containing humic substances was prepared by diluting peat extract.



11 Influence of foreign substances

Tolerable concentration of foreign substances in mg/l - matrix influence

for ammonium		for carbonate hardness		for total hardness		for nitrate	
Al ³⁺	100	Al ³⁺	10	Al ³⁺	100	Al ³⁺	10
Ca ²⁺	100					Ca ²⁺	100
Cl ⁻	1000						
Cr ³⁺	100	Cr ³⁺	100	Cr ³⁺	10	Cr ³⁺	1
Cr ₂ O ₇ ²⁻	100	Cr ₂ O ₇ ²⁻	10	Cr ₂ O ₇ ²⁻	100	Cr ₂ O ₇ ²⁻	1
Cu ²⁺	100	Cu ²⁺	1000	Cu ²⁺	1	Cu ²⁺	10
F ⁻	1000	F ⁻	100	F ⁻	100	F ⁻	100
Fe ²⁺	10						
Fe ³⁺	100	Fe ³⁺	10	Fe ³⁺	10	Fe ³⁺	1
Mg ²⁺	100					Mg ²⁺	100
Mn ²⁺	10	Mn ²⁺	1000	Mn ²⁺	10	Mn ²⁺	100
Na ⁺	1000	Na ⁺	1000	Na ⁺	1000	Na ⁺	100
		NH ₄ ⁺	1000	NH ₄ ⁺	1000	NH ₄ ⁺	100
NO ₂ ⁻	100	NO ₂ ⁻	100	NO ₂ ⁻	1000	NO ₂ ⁻	0,5
NO ₃ ⁻	1000	NO ₃ ⁻	1000	NO ₃ ⁻	1000		
PO ₄ ³⁻	1000	PO ₄ ³⁻	1000	PO ₄ ³⁻	100	PO ₄ ³⁻	100
polyphosphates	1000	polyphosphates	1000	polyphosphates	100	polyphosphates	100
S ²⁻	1	S ²⁻	100	S ²⁻	100	S ²⁻	1
SiO ₃ ²⁻	1000	SiO ₃ ²⁻	100	SiO ₃ ²⁻	1000	SiO ₃ ²⁻	100
SO ₃ ²⁻	100	SO ₃ ²⁻	100	SO ₃ ²⁻	1000	SO ₃ ²⁻	100
SO ₄ ²⁻	1000						
Zn ²⁺	1000	Zn ²⁺	1000	Zn ²⁺	10	Zn ²⁺	100
free chlorine	100	free chlorine	1	free chlorine	1	free chlorine	1
EDTA	1000	EDTA	1000	EDTA	100	EDTA	10
cationic surfactants	100	cationic surfactants	10	cationic surfactants	10	cationic surfactants	10
anionic surfactants	10	anionic surfactants	100	anionic surfactants	100	anionic surfactants	100
oxidizing agents	100	oxidizing agents	1000	oxidizing agents	1000	oxidizing agents	10
seawater and brackish water: not suitable as sample material		seawater and brackish water: suitable as sample material		seawater and brackish water: suitable as sample material		seawater and brackish water: not suitable as sample material	
water containing humic substances: suitable as sample material		water containing humic substances: suitable as sample material		water containing humic substances: suitable as sample material		water containing humic substances: suitable as sample material	

11 Influence of foreign substances

Tolerable concentration of foreign substances in mg/l - matrix influence

en

for nitrite

Al ³⁺	1000
Ca ²⁺	1000
Cl ⁻	1000
Cr ³⁺	100
Cr ₂ O ₇ ²⁻	1
Cu ²⁺	1000
F ⁻	1000
Fe ²⁺	10
Fe ³⁺	1
Mg ²⁺	1000
Mn ²⁺	1000
Na ⁺	1000
NH ₄ ⁺	1000
NO ₃ ⁻	1000
PO ₄ ³⁻	1000
polyphosphates	1
S ²⁻	1
SiO ₃ ²⁻	100
SO ₃ ²⁻	10
SO ₄ ²⁻	1000
Zn ²⁺	1000

free chlorine	0,1
EDTA	1000
cationic surfactants	100
anionic surfactants	10
oxidizing agents	1

seawater and brackish water: suitable as sample material

water containing humic substances: suitable as sample material

for pH

free chlorine	1000
EDTA	1000
cationic surfactants	10
anionic surfactants	1000
oxidizing agents	1000
seawater and brackish water: suitable as sample material	
water containing humic substances: yields false-low results	

for phosphate

Al ³⁺	1000
Ca ²⁺	1000
Cl ⁻	1000
Cr ³⁺	1
Cr ₂ O ₇ ²⁻	10
Cu ²⁺	10
F ⁻	100
Fe ²⁺	10
Fe ³⁺	100
Mg ²⁺	1000
Mn ²⁺	1000
Na ⁺	1000
NH ₄ ⁺	1000
NO ₂ ⁻	1000
NO ₃ ⁻	1000
S ²⁻	1
SiO ₃ ²⁻	1000
SO ₃ ²⁻	1000
SO ₄ ²⁻	1000
Zn ²⁺	1000

free chlorine	100
EDTA	100
cationic surfactants	100
anionic surfactants	100
oxidizing agents	100

seawater and brackish water: suitable as sample material

water containing humic substances: suitable as sample material

for oxygen

Al ³⁺	100
Ca ²⁺	1000
Cl ⁻	1000
Cr ³⁺	1
Cr ₂ O ₇ ²⁻	1
Cu ²⁺	1000
F ⁻	10000
Fe ²⁺	1
Fe ³⁺	100
Mg ²⁺	1000
Mn ²⁺	1000
Na ⁺	1000
NH ₄ ⁺	1000
NO ₂ ⁻	10
NO ₃ ⁻	1000
PO ₄ ³⁻	1000
polyphosphates	1
S ²⁻	1
SiO ₃ ²⁻	1000
SO ₃ ²⁻	100
SO ₄ ²⁻	1000
Zn ²⁺	100

free chlorine	1
EDTA	10
cationic surfactants	10
anionic surfactants	10
oxidizing agents	0,1

seawater and brackish water: suitable as sample material

water containing humic substances: suitable as sample material

12 Method control

The correct function of the test reagents, the auxiliaries, and the mode of working can be checked easily for some of the tests described here. For this purpose, a corresponding standard solution is diluted to a concentration that lies roughly in the middle of the measuring range of the respective test. The resultant solution is then analyzed in the same way as a normal sample. If the measurement result equals the desired value (**concentration of the standard solution x dilution factor**), the reagents and auxiliaries are in good order and the analysis has been performed correctly.

In the case of the pH test, an **undiluted** buffer solution with a pH of 7.00 is analyzed at 20 °C.

By analyzing the water sample after the addition of a defined quantity of standard solution (standard addition, spiking), it is possible to check the tests for ammonium, nitrate, nitrite, and phosphate as to whether the measurement results are influenced by other substances present in the water sample (matrix effect). If there is no matrix effect, the recovery rate must be 100 %.

The standard solutions given below are available for the described control measurements.

Item	Cat. No.	Content / pH
Ammonium standard solution Certipur® Ammonium chloride in water	119812	1000 mg/l NH ₄ ⁺
Nitrate standard solution Certipur® Sodium nitrate in water	119811	1000 mg/l NO ₃ ⁻
Nitrite standard solution Certipur® Sodium nitrite in water	119899	1000 mg/l NO ₂ ⁻
Buffer solution pH 7.00 Certipur®	109439	pH 7.00 at 20 °C
Phosphate standard solution Certipur® Potassium dihydrogen phosphate in water	119898	1000 mg/l PO ₄ ³⁻

13 Refill packs and other reagents

Item	Cat. No.	Number of determinations / Package contents
MQuant® Ammonium Test with color card	108024	50 determinations
MQuant® Carbonate Hardness Test - Acid-binding capacity (ANC) with titration pipette	108048	300 determinations at 10 °d (12.5 °e) (ANC 3.6 mmol/l)
MQuant® Total Hardness Test with titration pipette	108039	300 determinations at 10 °d (12.5 °e)
MQuant® Total Hardness Test, H-1 Refill pack for 108039	111122	600 determinations in combination with 108203
MQuant® Total Hardness Test, H-2 Refill pack for 108039	108203	600 determinations in combination with 111122
MQuant® Nitrate Test with color card	111170	200 determinations
MQuant® Nitrite Test with color card	108025	200 determinations
MQuant® pH Test with color card	108027	400 determinations
MQuant® Phosphate Test in freshwater and seawater with color card	114661	100 determinations
MQuant® Oxygen Test with Oxygen Reaction Bottle and with titration pipette	111107	100 determinations at 8.5 mg/l O ₂
MQuant® Oxygen Test Refill pack for 111107 without Oxygen Reaction Bottle and without titration pipette	111152	100 determinations at 8.5 mg/l O ₂
MQuant® Oxygen Reaction Bottle	114663	1 bottle
MQuant® Flat-bottom tubes with screw caps for MQuant® tests with color-disk comparator	117988	12 test tubes
MQuant® Universal indicator strips pH 0 - 14	109535	100 strips
MQuant® pH-indicator strips pH 4.0 - 7.0	109542	100 strips
MQuant® Total Hardness Test test strips with color card	110025	100 determinations
MQuant® Carbonate Hardness Test - Acid-binding capacity (ANC) with dropping bottle	111103	100 determinations at 10 °d (12.5 °e) (ANC 3.6 mmol/l)
Sodium hydroxide solution 1 mol/l Titripur®	109137	1 l and up
Hydrochloric acid 1 mol/l Titripur®	109057	1 l and up
Sulfuric acid 0.5 mol/l Titripur®	109072	1 l and up

Auxiliary tables

1 Orientational values for grading the quality of water bodies

Quality class	I	II	III	IV
Organic load	un polluted to very slightly polluted	moderately polluter	strongly polluted	extremely polluted
BOD ₅ value in mg/l	1 - 2	2 - 8	8 - 20	> 20
Oxygen minimum in mg/l	> 8	> 6	> 2	< 2
Oxygen saturation in %	86 - 100 100 - 110	50 - 85 110 - 150	20 - 40 150 - 200	< 10 > 230
pH	6.5 - 7.0 acidic 7.0 - 7.5 alkaline	6.0 - 6.5 8.0 - 8.5	5.0 - 5.5 9.0 - 9.5	< 5.0 10.0
Ammonium in mg/l	< 0.1	0.1 - 1	> 2	> 5
Nitrate in mg/l	< 1.0	1 - 5	> 5	
Nitrite in mg/l	< 0.1	0.2 - 0.5	4.0 - 6.0	8.0
Orthophosphate in mg/l	< 0.03	< 0.5	> 0.5	
Total hardness in mmol/l	approx. 3.6	approx. 5.3	approx. 7.1	
Acid-binding capacity (ANC) in mmol/l	0.5 - 1.0	0.25 - 0.5	0.03 - 0.1	0.05
Iron in mg/l	0 - 0.1	0.1 - 0.2	approx. 0.5	1.0
Chloride in mg/l	< 80	80 - 500	1500 - 3500	> 3500

en

2 Conversion of hardness values

Conversion	mmol/l Ca ²⁺ + Mg ²⁺	mg/l (ppm) Ca ²⁺	Germ. degree °d	Engl. degree °e	French degree °f	mg/l (ppm) CaCO ₃
1 mmol/l Ca ²⁺ + Mg ²⁺	1	40.08	5.61	7.02	10.01	100.1
1 mg/l (ppm) Ca ²⁺	0.025	1	0.140	0.175	0.250	2.50
1 German degree °d	0.178	7.15	1	1.25	1.78	17.85
1 English degree °e	0.142	5.71	0.799	1	1.43	14.25
1 French. degree °f	0.100	4.00	0.560	0.702	1	10.00
1 mg/l (ppm) CaCO ₃	0.010	0.400	0.056	0.070	0.100	1

3 Factors for the approximate calculation of the concentration of free carbonic acid (CO₂) from the acid-binding capacity (ANC) as a function of pH (from Hütter, 1990)

pH	Factor	pH	Factor	pH	Factor	pH	Factor
6.1	94	6.9	30.0	7.1	9.4	7.6	3.0
6.2	75	6.7	24.0	7.2	7.5	7.7	2.4
6.3	59	6.8	19.0	7.3	5.9	7.8	1.9
6.4	47	6.9	15.0	7.4	4.7	7.9	1.5
6.5	37	7.0	12.0	7.5	3.7	8.0	1.2

Example:

Measured values: ANC 1.5 mmol/l; pH 7.1

Factor from table = 9.4

Concentration of free carbonic acid = ANC x factor = 1.5 mmol/l x 9.4 = 14.1 mg/l CO₂

Auxiliary tables

4 Oxygen saturation water concentration of water (in mg/l) as a function of water temperature (acc. to Oehme and Schuler, 1983)

The stated values relate to oxygen concentrations of pure water in equilibrium with atmospheric air (air-saturated water and water-vapour-saturated atmosphere) and apply for standard pressure, i.e. 1013 hPa (1013 mbar resp. 760 Torr).

There are slight variations in the values given in diverse publications for the oxygen saturation concentration of water. The data in the table correspond to the latest scientific status.

Temperature °C	.0	.1	.2	.3	.4	.5	.6	.7	.8	.9
0	14.64	14.60	14.55	14.51	14.47	14.43	14.39	14.35	14.31	14.27
1	14.23	14.19	14.15	14.10	14.06	14.03	13.99	13.95	13.91	13.87
2	13.83	13.79	13.75	13.71	13.68	13.64	13.60	13.56	13.52	13.49
3	13.45	13.41	13.38	13.34	13.30	13.27	13.23	13.20	13.16	13.12
4	13.09	13.05	13.02	12.98	12.95	12.92	12.88	12.85	12.81	12.78
5	12.75	12.71	12.68	12.65	12.61	12.58	12.55	12.52	12.48	12.45
6	12.42	12.39	12.36	12.32	12.29	12.26	12.23	12.20	12.17	12.14
7	12.11	12.08	12.05	12.02	11.99	11.96	11.93	11.90	11.87	11.84
8	11.81	11.78	11.75	11.72	11.69	11.67	11.64	11.61	11.58	11.55
9	11.53	11.50	11.47	11.44	11.42	11.39	11.36	11.33	11.31	11.28
10	11.25	11.23	11.20	11.18	11.15	11.12	11.10	11.07	11.05	11.02
11	10.99	10.97	10.94	10.92	10.89	10.87	10.84	10.82	10.79	10.77
12	10.75	10.72	10.70	10.67	10.65	10.63	10.60	10.58	10.55	10.53
13	10.51	10.48	10.46	10.44	10.41	10.39	10.37	10.35	10.32	10.30
14	10.28	10.26	10.23	10.21	10.19	10.17	10.15	10.12	10.10	10.08
15	10.06	10.04	10.02	9.99	9.97	9.95	9.93	9.91	9.89	9.87
16	9.85	9.83	9.81	9.78	9.76	9.74	9.72	9.70	9.68	9.66
17	9.64	9.62	9.60	9.58	9.56	9.54	9.53	9.51	9.49	9.47
18	9.45	9.43	9.41	9.39	9.37	9.35	9.33	9.31	9.30	9.28
19	9.26	9.24	9.22	9.20	9.19	9.17	9.15	9.13	9.11	9.09
20	9.08	9.06	9.04	9.02	9.01	8.99	8.97	8.95	8.94	8.92
21	8.90	8.88	8.87	8.85	8.83	8.82	8.80	8.78	8.76	8.75
22	8.73	8.71	8.70	8.68	8.66	8.65	8.63	8.62	8.60	8.58
23	8.57	8.55	8.53	8.52	8.50	8.49	8.47	8.46	8.44	8.42
24	8.41	8.39	8.38	8.36	8.35	8.33	8.32	8.30	8.28	8.27
25	8.25	8.24	8.22	8.21	8.19	8.18	8.16	8.15	8.14	8.12
26	8.11	8.09	8.08	8.06	8.05	8.03	8.02	8.00	7.99	7.98
27	7.96	7.95	7.93	7.92	7.90	7.89	7.88	7.86	7.85	7.83
28	7.82	7.81	7.79	7.78	7.77	7.75	7.74	7.73	7.71	7.70
29	7.69	7.67	7.66	7.65	7.63	7.62	7.61	7.59	7.58	7.57
30	7.55	7.54	7.53	7.51	7.50	7.49	7.48	7.46	7.45	7.44
31	7.42	7.41	7.40	7.39	7.37	7.36	7.35	7.34	7.32	7.31
32	7.30	7.29	7.28	7.26	7.25	7.24	7.23	7.21	7.20	7.19
33	7.18	7.17	7.15	7.14	7.13	7.12	7.11	7.09	7.08	7.07
34	7.06	7.05	7.04	7.02	7.01	7.00	6.99	6.98	6.97	6.96
35	6.94	6.93	6.92	6.91	6.90	6.89	6.88	6.87	6.85	6.84
36	6.83	6.82	6.81	6.80	6.79	6.78	6.77	6.75	6.74	6.73
37	6.72	6.71	6.70	6.69	6.68	6.67	6.66	6.65	6.64	6.63
38	6.61	6.60	6.59	6.58	6.57	6.56	6.55	6.54	6.53	6.52
39	6.51	6.50	6.49	6.48	6.47	6.46	6.45	6.44	6.43	6.42
40	6.41	6.40	6.39	6.38	6.37	6.36	6.35	6.34	6.33	6.32

Example:

Measured value: water temperature 10.5 °C; oxygen concentration 9 mg/l
 Oxygen saturation concentration from table = 11.12 mg/l



Auxiliary tables

4 Oxygen saturation concentration of water (in mg/l) as a function of water temperature (acc. to Oehme and Schuler, 1983)

The oxygen concentration measured at a specific water temperature and the oxygen saturation concentration given in the table for the same temperature can be used to calculate the oxygen saturation index (relative oxygen saturation in %):

$$\text{Oxygen saturation index} = \frac{\text{Oxygen concentration (measured value)} \times 100\%}{\text{Oxygen saturation concentration (from table)}}$$

Example:

Measured values: water temperature 10.5 °C; oxygen concentration 9 mg/l
 Oxygen saturation concentration from table = 11.12 mg/l
 Oxygen saturation index = $9 \times 100 / 11.12 = 80.9\%$

Assuming a constant oxygen concentration, according to the equation given above the oxygen saturation index increases when the oxygen saturation concentration of water decreases. The latter is the case at increasing height above sea level, i.e. when the atmospheric pressure drops.

Table 5 gives the correction factors for the oxygen saturation index as applicable for various heights above sea level.

Dissolved salts reduce the oxygen saturation concentration.

5 Correction factors for the oxygen saturation index as a function of height above sea level resp. of atmospheric pressure (from Schwoerbel, 1979)

Height m	Pressure hPa (mbar)	Factor	Height m	Pressure hPa (mbar)	Factor
0	1013	1.00	1300	862	1.17
100	1000	1.01	1400	852	1.19
200	988	1.03	1500	841	1.20
300	976	1.04	1600	830	1.22
400	964	1.05	1700	820	1.24
500	952	1.06	1800	810	1.25
600	940	1.08	1900	801	1.26
700	928	1.09	2000	7.92	1.28
800	916	1.11	2100	782	1.30
900	905	1.12	2200	773	1.31
1000	894	1.12	2300	764	1.33
1100	884	1.15	2400	754	1.34
1200	873	1.16	2500	746	1.36

Example:

Height above sea level 400 m resp. atmospheric pressure 964 hPa; calculated oxygen saturation index 80.9%

Corrected oxygen saturation index = calculated oxygen saturation index x factor from table = $80.9\% \times 1.05 = 84.9\%$

Conversion of different pressure units:

1 hPa (hectopascal) = 1 mbar (millibar) = 0.75 Torr

1 Torr = 1 mm Hg = 1.333 hPa

Auxiliary tables

6 Optimum ranges, threshold values, and lethal limits of pH and water temperature for carp and rainbow trout (from Steffens, 1981)

Fish species	pH Optimum range	Threshold value	Lethal limit
Carp	6.5 - 8.0	5.5;10.0	4.8;10.8
Rainbow trout	6.5 - 7.5	5.5;9.0	4.8;9.2

Fish species	Water temperature in °C Optimum range	Threshold value	Lethal limit
Carp	22 - 28	0; 36	38
Rainbaow trout	12 - 16	20	26

* with habituation

7 Limits for free ammonia (NH₃) for various fish species (from Bohl, 1982)

Fish species	Limit in mg/l NH ₃
Rainbow trout, fry (rt ₀₋₁)	0.006
Rainbow trout, 1 - 2 years old (rt ₁₋₂)	0.01
Carp	0.02
Eel	0.01



Auxiliary tables

8 Percentage of free ammonia (NH₃) in the total ammonium concentration as a function of water temperature and pH (from Steffens, 1981)

Temperature °C	pH 6.0	6.5	7.0	7.5	8.0	8.5	9.0	9.5	10.0
0	0.00827	0.0261	0.0826	0.261	0.820	2.55	7.64	20.7	45.3
1	0.00899	0.0284	0.0898	0.284	0.891	2.77	8.25	22.1	47.3
2	0.00977	0.0309	0.0977	0.308	0.968	3.00	8.90	23.6	49.4
3	0.0106	0.0336	0.106	0.335	1.05	3.25	9.60	25.1	51.5
4	0.0115	0.0364	0.115	0.363	1.14	3.52	10.3	26.7	53.5
5	0.0125	0.0395	0.125	0.394	1.23	3.80	11.1	28.3	55.6
6	0.0136	0.0429	0.135	0.427	1.34	4.11	11.9	30.0	57.6
7	0.0147	0.0464	0.147	0.462	1.45	4.44	12.8	31.7	59.5
8	0.0159	0.0503	0.159	0.501	1.57	4.79	13.7	33.5	61.4
9	0.0172	0.0544	0.172	0.542	1.69	5.16	14.7	35.3	63.3
10	0.0186	0.0589	0.186	0.586	1.83	5.56	15.7	37.1	65.1
11	0.0201	0.0637	0.201	0.633	1.97	5.99	16.8	38.9	66.8
12	0.0218	0.0688	0.217	0.684	2.13	6.44	17.9	40.8	68.5
13	0.0235	0.0743	0.235	0.738	2.30	6.92	19.0	42.6	70.2
14	0.0254	0.0802	0.253	0.796	2.48	7.43	20.2	44.5	71.7
15	0.0274	0.0865	0.273	0.859	2.67	7.97	21.5	46.4	73.3
16	0.0295	0.0933	0.294	0.925	2.87	8.54	22.8	48.3	74.7
17	0.0318	0.101	0.317	0.996	3.08	9.14	24.1	50.2	76.1
18	0.0343	0.108	0.342	1.07	3.31	9.78	25.5	52.0	77.4
19	0.0369	0.117	0.368	1.15	3.56	10.5	27.0	53.9	78.7
20	0.0397	0.125	0.396	1.24	3.82	11.2	28.4	55.7	79.9
21	0.0427	0.135	0.425	1.33	4.10	11.9	29.9	57.5	81.0
22	0.0459	0.145	0.457	1.43	4.39	12.7	31.5	59.2	82.1
23	0.0493	0.156	0.491	1.54	4.70	13.5	33.0	60.9	83.2
24	0.0530	0.167	0.527	1.65	5.03	14.4	34.6	62.6	84.1
25	0.0569	0.180	0.566	1.77	5.38	15.3	36.3	64.3	85.1
26	0.0610	0.193	0.607	1.89	5.75	16.2	37.9	65.9	85.9
27	0.0654	0.207	0.651	2.03	6.15	17.2	39.6	67.4	86.8
28	0.0701	0.221	0.697	2.17	6.56	18.2	41.2	68.9	87.5
29	0.0752	0.237	0.747	2.32	7.00	19.2	42.9	70.4	88.3
30	0.0805	0.254	0.799	2.48	7.46	20.3	44.6	71.8	89.0

Example:

Measured values: water temperature 12 °C; pH 7.5; ammonium concentration 2 mg/l

Percentage of free ammonia from table = 0.684 %

Concentration of free ammonia = measured ammonium concentration x percentage from table / 100 = 2 mg/l x 0.684 / 100 = 0.014 mg/l NH₃

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Merck KGaA, 64271 Darmstadt, Germany,
Tel. +49(0)6151 72-2440

www.analytical-test-kits.com

EMD Millipore Corporation, 400 Summit Drive
Burlington MA 01803, USA, Tel. +1-978-715-4321

Sigma-Aldrich Canada Co. or Millipore (Canada) Ltd.
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Tel. +49(0)6151 72-2440

www.analytical-test-kits.com

EMD Millipore Corporation, 400 Summit Drive
Burlington MA 01803, USA, Tel. +1-978-715-4321
Sigma-Aldrich Canada Co. or Millipore (Canada) Ltd.
2149 Winston Park, Dr. Oakville, Ontario, L6H 6J8
Phone: +1 800-565-1400

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