

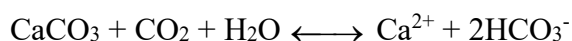
Determination of total water hardness via chelatometry

Task:

Determine in mmol.l^{-1} the total water hardness; determine in mg.l^{-1} the calcium and magnesium content in drinking water.

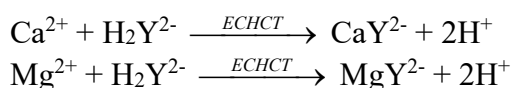
Principle:

The total water hardness is caused not only by Ca^{2+} and Mg^{2+} salts contained in water, but by Sr^{2+} and Ba^{2+} as well. Their presence depends on the amount of dissolved CO_2 , which balances the reaction:



Water hardness is determined via direct titration of volumetric solution chelaton 3 in the dampening ammonia solution using the Eriochromium black T indicator.

Reaction equation:



If we want to determine Ca^{2+} only, we titrate it using murexid or fluorexon indicator at 12 - 13 pH. At this pH, the concurrently present Mg^{2+} ions condense as $\text{Mg}(\text{OH})_2$ (\downarrow white) so only Ca^{2+} is titrated. We calculate the amount of Mg^{2+} in the sample according to the difference in volume of a volumetric solution / murexid.

Tools:

Titration flasks, burette, pipette (100 ml), graduated cylinder (5 ml).

Chemicals:

Chelaton 3 $c = 0.05 \text{ mol.l}^{-1}$, Eriochromium black T, dampening ammonia solution.

Sample:

Drinking water.

Procedure:

- 1) Prepare 250 ml of chelaton 3 volumetric solution with the concentration of 0.05 mol.l^{-1} .
- 2) Calculate the real concentration of chelaton 3 from its real weight.
- 3) Pipette 100 ml of tested water into a titration flask.
- 4) Add 5 ml of dampening ammonia solution by a graduated cylinder.
- 5) Add a small amount of Eriochromium black T and titrate from wine red to blue colouring which lasts for 1 min.
- 6) Determine 3x. Calculate water hardness in mmol.l^{-1} .

Assessment:

Calculation:

Weight of chelaton 3:

$$m(\text{g}) = c * V * M \quad (\text{the volume in litres})$$

The real concentration of chelaton 3:

$$c(\text{real}) = c(\text{theoretical}) * m(\text{real}) / m(\text{theoretical})$$

Calculation of total water hardness c in mmol.l^{-1} :

$$c = \frac{c_{\text{CH}_3} \cdot V_{\text{CH}_3}}{V_{\text{water}}} \cdot 1000$$

where: c_{CH_3} – concentration of chelaton 3 in mol.l^{-1}
 V_{CH_3} – consumption of chelaton 3 in ml
 V_{water} – volume of water sample in ml

In the past, water hardness was determined in German degrees $^{\circ}\text{N}$, when:
 $1^{\circ}\text{N} = 1 \text{ mg CaO} / 100 \text{ ml water}$ and $1 \text{ mmol.l}^{-1} = 5.6^{\circ}\text{N}$

Tab. 1: Types of water according to hardness

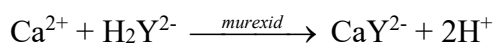
Water hardness	Water hardness in mmol.l^{-1}	Water hardness in $^{\circ}\text{N}$
Very soft	0 – 0.7	0 - 4
Soft	0.7 – 1.4	4 – 8
Medium soft	1.4 – 2.1	8 - 12
Quite hard	2.1 – 3.2	12 – 18
Hard	3.2 – 5.4	18 – 30
Very hard	> 5.4	> 30

Ministry of Health Regulation 252/2004 suggests drinking water hardness 2-3.5 mmol.l^{-1} (11.2 $^{\circ}\text{N}$ – 19.6 $^{\circ}\text{N}$).

Determination of Ca^{2+}

Principle:

Calcium is a natural part of water contributing to its hardness. Ca^{2+} is titrated by volumetric solution chelaton 3 using murexid indicator in the diluted NaOH at pH 12.



Tools:

Titration flasks, pipettes (100 ml, 2 ml), graduated cylinder (100 ml), burette.

Chemicals:

NaOH ($c = 0.1 \text{ mol.l}^{-1}$), HCl ($c = 0.1 \text{ mol.l}^{-1}$), NaOH ($c = 5 \text{ mol.l}^{-1}$), murexid, chelaton 3 ($c = 0.05 \text{ mol.l}^{-1}$).

Procedure:

Pipette 100 ml of water sample into a titration flask. Add 2 ml 5 M NaOH, murexid indicator and titrate by 0.05 M chelaton 3 to blue-violet colouring.

Assessment:

Calculate the amount of Ca^{2+} in mol.l^{-1} or in mg.l^{-1} .

Determination of Mg^{2+}

Magnesium causes water hardness. We determine it via complexometry or by calculating the difference of consumption using Eriochromium black T and murexid.

Assessment:

$$V(\text{Mg}^{2+}) = V(\text{water hardness}) - V(\text{Ca}^{2+})$$