# Application Bulletin 303 e

# Comprehensive tap water analysis inclusively oxygenated halides with TitrIC 2

Branch: water, waste water, environmental protection

***Keywords***

TitrIC 2 / 861 / 855 / 712 / 800 / Aquatrode plus / 6.0257.000 / Dosino / tiamo / 6.1006.630 / Metrosep SUPP 7 – 250 / 6.1010.230 / Metrosep C 2 – 250 / 2.145.0320 / 853 / MCS / branch 2

***Summary***

The determination of anions / cations in tap water was done on the **Metrosep SUPP 7 – 250** / **Metrosep C 2 – 250** using carbonate / tartaric acid – dipicolinic acid eluent with chemical suppression. **TitrIC 2** enables a fully automated and parallel analysis of anions, cations, titration (p- and m-value), and direct measurements (temperature, pH, conductivity). In this application the determination of oxygenated halides is shown as well. For a faster analysis of the standard anions please refer to **AB 302 e**.

***Sample***

Sample 1: Tap water Herisau

Sample 2: Tap water Rondelle

***Reagents***

Eluent: **3.6 mmol/L sodium carbonate** in ultra pure water (resistivity >18 MΩ)

**7 mM tartaric acid, 1.5 mM dipicolinic acid** in ultra pure water

Suppressor solutions:
50 mmol/L sulfuric acid
ultra pure water

Titration: 0.1 mol/L HCl for p-/m-value determination
1 mol/L $HNO_3$ for acidification

***Standards*** [ppm] in ultra pure water

Anions:

| Analyte / Level | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| fluoride | 0.03 | 0.1 | 0.2 | 0.4 | 0.6 |
| chlorite | 0.005 | 0.01 | 0.02 | 0.05 | 0.1 |
| bromate | 0.005 | 0.01 | 0.02 | 0.05 | 0.1 |
| chloride | 3 | 6 | 10 | 20 | 30 |
| nitrite | 0.03 | 0.1 | 0.2 | 0.4 | 0.6 |
| bromide | 0.03 | 0.1 | 0.2 | 0.4 | 0.6 |
| chlorate | 0.005 | 0.01 | 0.02 | 0.05 | 0.1 |
| nitrate | 3 | 6 | 10 | 20 | 30 |
| phosphate | 0.06 | 0.2 | 0.4 | 0.8 | 1.2 |
| sulfate | 3 | 6 | 10 | 20 | 30 |

Cations:

| Analyte / Level | **1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|
| sodium | 1 | 2 | 4 | 6 | 8 |
| potassium | 0.5 | 1 | 2 | 3 | 4 |
| calcium | 12.5 | 25 | 50 | 75 | 100 |
| magnesium | 3.75 | 7.5 | 15 | 22.5 | 30 |

***Apparatus and Accessories***

***- delivered with TitrIC 2 package:***

| | |
|---|---|
| 861 Adv. Compact IC with seq. supp. | 2.861.0020 |
| 861 Adv. Compact IC | 2.861.0010 |
| 855 Robotic Titrosampler | 2.855.0020 |
| 712 Conductometer | 2.712.0010 |
| Cond. measuring cell Pt 1000 | 6.0912.110 |
| Conductivity standard | 6.2301.060 |
| Aquatrode plus | 6.0257.000 |
| 3 Dosions | 2.800.0010 |
| *tiamo* 1.1 full | 6.6056.112 |
| USB Converter Edgeport/4 | 2.145.0320 |
| 802 Rod Stirrer | 2.802.0020 |

***- used optional accessories for TitrIC 2:***

| | |
|---|---|
| Metrosep A SUPP 7 – 250 | 6.1006.630 |
| Metrosep RP Guard | 6.1011.020 |
| Metrosep C 2 – 250 | 6.1010.230 |
| Metrosep C 2 Guard | 6.1010.200 |
| Sample rack 59 x 120 mL | 6.2041.840 |
| Sample beaker 120 mL (x100) | 6.1459.300 |
| Column oven for 861 | 2.861.0500 |
| 853 MCS $CO_2$ Suppressor | 2.853.0010 |

***Sample Preparation***

The water samples were injected directly.

***Analysis***

The standards and the sample were injected two 800 dosinos (10 and 50 mL Dosing unit) with automatic acidification for the cation run prior to injection. Loop volume anions: **20 µl**, cations: **10 µl**. The two (with the TitrIC 2 package delivered) *tiamo* methods *TitrIC 2 – complete run* and *TitrIC 2 – IC calibraton anion & cation* were used for all types of analysis mentioned.

***Calculation (IC)***

Automatic integration with IC Net 2.3 software using peak area.

***Parameters***

IC - Anions

```
STARTUP HARDWARE:
  RECORDER  METHOD  ASupp7_250-TitrIC.mtw
 RECORDER  DATA     Data acquisition  [Cond]
  861 Adv. Compact Unit version           4
  861 Adv. Compact Polarity               +
  861 Adv. Compact Supp. autostep       yes
  861 Adv. Compact Autostep with       Fill
  861 Adv. Compact Peristaltic pump     yes
  861 Adv. Compact Flow       0.70 mL/min
  861 Adv. Compact Pmax         15.0 MPa
  861 Adv. Compact Pmin          0.0 MPa
  861 Adv. Compact FullScale    50 uS/cm
  861 Adv. Compact Remote       00001000
  Column Thermostat Temperature  45.0 °C
```

```
START WITH DETERMINATION
0.0    Column Thermostat  START
0.20   861 Adv. Compact   Valve    Inject
28.0   861 Adv. Compact   Valve     Fill
```

```
START WITH INJECT:
0.0   RECORDER     START
```

IC - Cations

```
STARTUP HARDWARE:
  RECORDER  METHOD C2_250-TitrIC.mtw
 RECORDER  DATA     Data acquisition  [Cond]
  861 Adv. Compact Unit version           1
  861 Adv. Compact Polarity               -
  861 Adv. Compact Supp. autostep       no
  861 Adv. Compact Autostep with       Fill
  861 Adv. Compact Flow       1.0 mL/min
  861 Adv. Compact Pmax         25.0 MPa
  861 Adv. Compact Pmin          0.0 MPa
  861 Adv. Compact FullScale   1000uS/cm
  861 Adv. Compact Remote       00000000
```

```
START WITH DETERMINATION

0.20   861 Adv. Compact   Valve    Inject
25.2   861 Adv. Compact   Valve     Fill
```

```
START WITH INJECT:
0.0   RECORDER     START
```

SET pH 4,3(HCl) – Titration (m-value)

| Control parameters | |
|---|---|
| EP1 at pH | 4.3 |
| Titration rate | user |
| Dynamics pH | 1.00 |
| Max. rate | 10.00 mL/min |
| Min rate | 15.00 µL/min |
| Stop criterion | drift |
| Stop drift | 30 µL/min |
| End point 2 | off |

SET pH 8,2 (HCl) – Titration (p-/m-value)

| Control parameters: | |
|---|---|
| EP1 at pH | 8.2 |
| Titration rate | user |
| Dynamics pH | 1.00 |
| Max. rate | 10.00 mL/min |
| Min rate | 15.00 µL/min |
| Stop criterion | drift |
| Stop drift | 30 µL/min |
| End point 2 | on |
| EP2 at pH | 4.3 |
| Dynamics pH | 1.00 |
| Max. rate | 10.00 mL/min |
| Min rate | 15.00 µL/min |
| Stop criterion | drift |
| Stop drift | 30 µL/min |

MEAS pH

| Measuring parameters: | |
|---|---|
| Measurement with drift control | on |
| Signal drift | 10.0 mV/min |
| Min. waiting time | 15 s |
| Max. waiting time | 52 s |
| Measuring interval | 2.0 s |
| Stop measured value pH | off |
| Measurement without drift control | off |
| Temperature | 25.0 °C |

MEAS conductivity

| Measuring parameters: | |
|---|---|
| Measurement frequency | auto |
| Measuring time | 35 s |
| Measuring interval | 2.0 s |
| Stop measured value | off mS/cm |
| Temperature | 20.0 °C |

### *Results*

TitrIC-Report

| | |
|---|---|
| Print date | 4/11/2006 |
| **General data** | |
| ID | Tap water Herisau |
| Record date | 4/05/2006 |
| Record time | 14:35:14 |
| User comment | |
| System comment | recalculated, within limit |
| **Titration data** | |
| pH | 7.88 |
| Cond. [µS/cm] | 588 |
| Temp. [°C] | 22.79 |
| m value [mmol/L] | 5.59 |
| p value [mmol/L] | 0 |

| | |
|---|---|
| **Anions** | |
| F [mg/L] | 0.056 |
| ClO2 [mg/L] | 0 |
| BrO3 [mg/L] | 0 |
| Cl [mg/L] | 13.11 |
| NO2 [mg/L] | 0 |
| Br [mg/L] | 0.004 |
| ClO3 [mg/L] | 0.004 |
| NO3 [mg/L] | 10.136 |
| PO4 [mg/L] | 0 |
| SO4 [mg/L] | 5.271 |
| Anion balance [mEq/L] | 6.07 |
| **Cations** | |
| Na [mg/L] | 6.21 |
| K [mg/L] | 0 |
| Mg [mg/L] | 17.49 |
| Ca [mg/L] | 86.502 |
| Cation balance [mEq/L] | 6.03 |
| ionic difference [mEq/L] | -0.04 |
| **ionic difference [%]** | -0.35 |

TitrIC-Report: Sample 1

TitrIC-Report

| | |
|---|---|
| Print date | 4/11/2006 |
| **General data** | |
| ID | Quelle Rondelle |
| Record date | 4/05/2006 |
| Record time | 14:36:17 |
| User comment | |
| System comment | recalculated, within limit |
| **Titration data** | |
| pH | 7.82 |
| Cond. [µS/cm] | 469 |
| Temp. [°C] | 24.01 |
| m value [mmol/L] | 4.12 |
| p value [mmol/L] | 0 |

| | |
|---|---|
| **Anions** | |
| F [mg/L] | 0.054 |
| ClO2 [mg/L] | 0 |
| BrO3 [mg/L] | 0 |
| Cl [mg/L] | 14.235 |
| NO2 [mg/L] | 0 |
| Br [mg/L] | 0.005 |
| ClO3 [mg/L] | 0 |
| NO3 [mg/L] | 9.895 |
| PO4 [mg/L] | 0.009 |
| SO4 [mg/L] | 5.694 |
| Anion balance [mEq/L] | 4.66 |
| **Cations** | |
| Na [mg/L] | 6.559 |
| K [mg/L] | 1.292 |
| Mg [mg/L] | 13.6 |
| Ca [mg/L] | 65.188 |
| Cation balance [mEq/L] | 4.69 |
| ionic difference [mEq/L] | 0.03 |
| **ionic difference [%]** | 0.31 |

TitrIC-Report: Sample 2

## Sample 1 - Tap water Herisau:

**Reproducibility:** Measurement of 10 tap water samples:

IC:

| anions | fluoride | chlorite | bromate | chloride | nitrite | bromide | chlorate | nitrate | phosphate | sulfate |
|---|---|---|---|---|---|---|---|---|---|---|
| Average (N=10) | **0.060** | **0.000** | **0.000** | **13.066** | **0.000** | **0.005** | **0.009** | **10.149** | **0.005** | **5.285** |
| Standard Deviation | 0.003 | 0.000 | 0.000 | 0.054 | 0.000 | 0.000 | 0.001 | 0.050 | 0.001 | 0.041 |
| % RSD (N=10) | 4.43 | - | - | 0.41 | - | 1.11 | 3.87 | 0.49 | 15.31 | 0.78 |

| cations | sodium | potassium | calcium | magnesium |
|---|---|---|---|---|
| Average (N=10) | 6.228 | 1.729 | 84.911 | 17.424 |
| Standard Deviation | 0.104 | 0.098 | 0.896 | 0.260 |
| % RSD (N=10) | 1.67 | 5.72 | 1.06 | 1.51 |

Titration / ionic balance:

| | pH | Cond. [µS/cm] | Temp. [°C] | m value [mmol/L] | p value [mmol/L] | sum anions [meq/L] | sum cations [meq/L] | ionic difference [%] |
|---|---|---|---|---|---|---|---|---|
| Average (N=10) | **7.772** | **585.900** | **22.358** | **5.572** | **0.000** | **6.002** | **5.992** | **-0.082** |
| Standard Deviation | 0.075 | 2.601 | 0.235 | 0.020 | 0.000 | 0.057 | 0.048 | - |
| % RSD (N=10) | **0.97** | **0.44** | **1.05** | **0.37** | **-** | **0.95** | **0.80** | **-** |

**Recovery:** Spiked sample Tap water Herisau:

| Anions [ppm] | fluoride | chlorite | bromate | chloride | nitrite | bromide | chlorate | nitrate | phosphate | sulfate |
|---|---|---|---|---|---|---|---|---|---|---|
| sample (av. N=10) | 0.060 | 0.000 | 0.000 | 13.066 | 0.000 | 0.005 | 0.009 | 10.149 | 0.005 | 5.285 |
| spiked (av. N=4) | 0.084 | 0.006 | 0.005 | 15.917 | 0.023 | 0.029 | 0.014 | 13.044 | 0.050 | 8.088 |
| % RSD spiked | 1.39 | 5.64 | 5.08 | 0.29 | 1.02 | 1.73 | 4.85 | 0.11 | 2.66 | 0.12 |
| difference | 0.023 | 0.006 | 0.005 | 2.851 | 0.023 | 0.024 | 0.005 | 2.895 | 0.045 | 2.803 |
| theoretical spike | 0.025 | 0.005 | 0.005 | 3 | 0.025 | 0.025 | 0.005 | 3 | 0.05 | 3 |
| recovery % | **92.7** | **113.5** | **99.0** | **95.0** | **92.3** | **96.1** | **92.5** | **96.5** | **89.8** | **93.4** |

| Cations [ppm] | sodium | potassium | calcium | magnesium |
|---|---|---|---|---|
| sample (av. N=10) | 6.228 | 1.729 | 84.911 | 17.424 |
| spiked (av. N=4) | 7.229 | 2.242 | 96.101 | 20.740 |
| difference | 1.001 | 0.513 | 11.190 | 3.316 |
| theoretical spike | 1 | 0.5 | 12.5 | 3.75 |
| recovery % | **100.1** | **102.6** | **89.5** | **88.4** |

## Sample 2 - Tap water Rondelle:

IC:

| Anions [ppm] | fluoride | chlorite | bromate | chloride | nitrite | bromide | chlorate | nitrate | phosphate | sulfate |
|---|---|---|---|---|---|---|---|---|---|---|
| Average (N=10) | **0.054** | **0.000** | **0.000** | **14.235** | **0.000** | **0.005** | **0.000** | **9.895** | **0.009** | **5.694** |

| Cations [ppm] | sodium | potassium | calcium | magnesium |
|---|---|---|---|---|
| Average (N=10) | 6.559 | 1.292 | 65.188 | 13.600 |

Titration / ionic balance:

| | pH | Cond. [µS/cm] | Temp. [°C] | m value [mmol/L] | p value [mmol/L] | sum anions [meq/L] | sum cations [meq/L] | ionic difference [%] |
|---|---|---|---|---|---|---|---|---|
| Average (N=10) | **7.82** | **469** | **24.01** | **4.12** | **0.00** | **4.66** | **4.69** | **0.31** |

***Comments***

This Application Bulletin is based on AW CH6-0864-042006.

Overview of the determined parameters:

- direct measurement:
  conductivity, pH, temperature
- titrations:
  p- and m-value (= acidic capacity)
- IC:
  fluoride, chlorite, bromate, chloride, nitrite, chlorate, bromide, nitrate, sulfate
  sodium, potassium, calcium, magnesium

TitrIC is absolutely flexible and can be adapted to determine the desired variables.

The calibration results are good which means that the filling of a loop with dosinos is working properly.

No sample preparation is necessary – even the acidification for the cation-IC-run is done automatically by a Dosino.

The recovery as well as the reproducibility for phosphate in tap water is poor while the calibration was good. There seems to be species in the sample which lower the phosphate concentrations. This problem (probably related to the presence of humic acids in the sample) is known and also appears with direct injection.

With this setup the oxohalogenides can be determined down to 5ppb. This could be improved with implementing an Advanced Modular system.

The ionic balance shown in the TitrIC-Report is calculated by comparison of total equivalent of anions (the carbonate concentration is calculated from the p- and m-values) and cations from the IC results:

Ionic d. [%]=100*( sum cations [meq/L] - sum anions [meq/L] ) /
( sum cations [meq/L] + sum anions [meq/L] )

Example: If 5 ppm sulfate is found, this corresponds to 5 mg/L → 0.052 mmol/L ($M(SO_4)$ = 96 mg/mmol) → -0.104 meq/L (charge $SO_4$: -2).

For a more detailed information about the system setup of TitrIC 2 consult the document ***AB 286 - Installation Instructions for TitrIC 2***.

For Application works of TitrIC 1 please have a look at AB 288 e.

The Aquatrode should be stored in the storage solution of Metrohm (6.2323.000).

***Appendix***

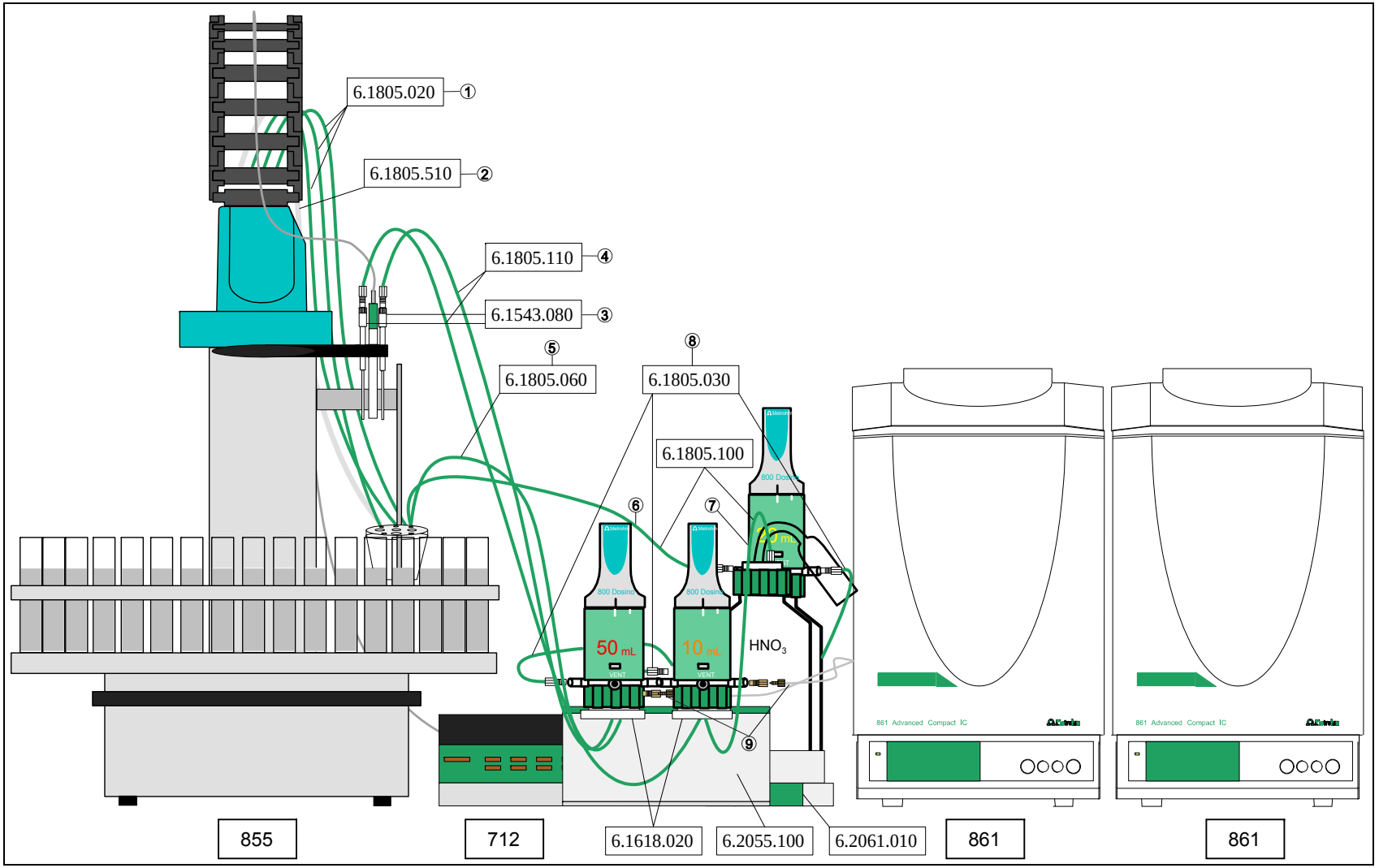
Calibration curves, reproducibility, chromatograms with peak tables and titration curves

***Date***

Thursday, 2006-04-05

***Name***

A. Rumi; IC Marketing,
Metrohm Ltd.; CH-9101 Herisau

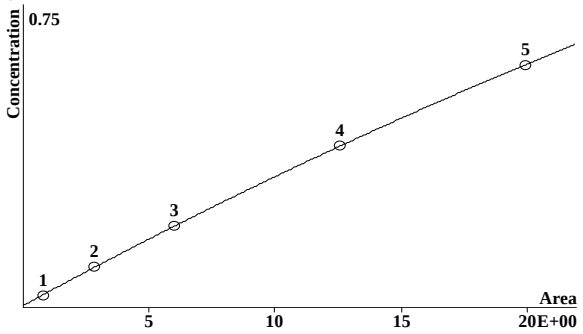



**TitrIC 2: System setup**

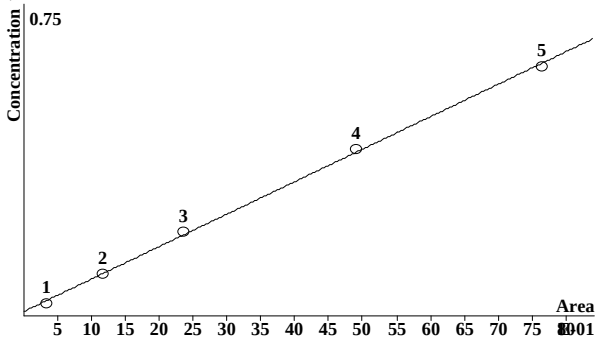
**Calibration**

**Anions:**

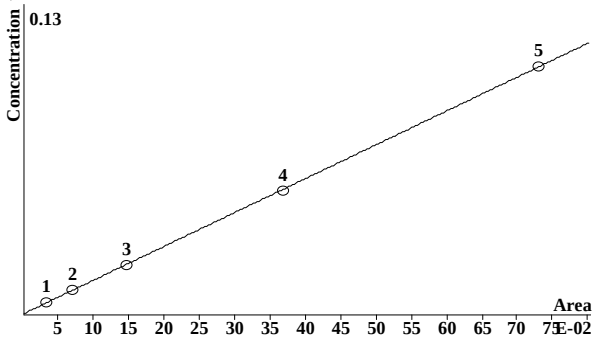
fluoride: RSD: 0.81%
Q = - 0.00020·A^2 + 0.034·A + 0.0038



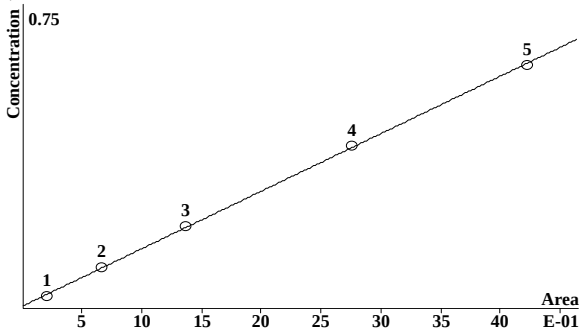

nitrite: RSD: 3.350 %, corr. coeff.: 0.99938
Q = 0.07824·A + 0.008926



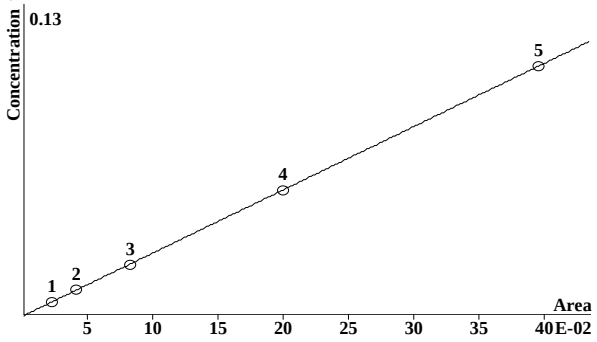

chlorite: RSD: 1.306 %, corr. coeff.: 0.999943
Q = 0.1362A + 0.000226



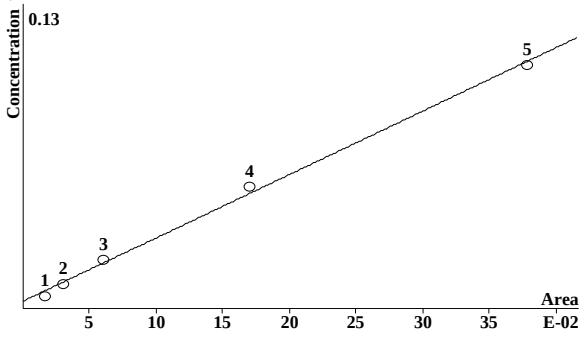

bromide: RSD: 1.804 %, corr. coeff.: 0.99984
Q = 0.1419·A + 0.004460



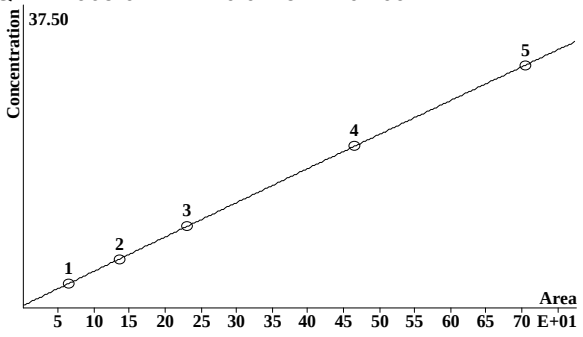

bromate: RSD: 0.496 % corr. coeff.: 0.999992
Q = 0.2546·A - 0.0006363



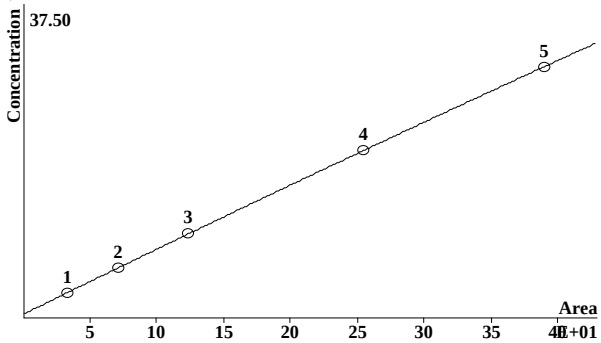

chlorate: RSD: 3.211 %, corr. coeff.: 0.99966
Q = 0.143708·A + 0.000734



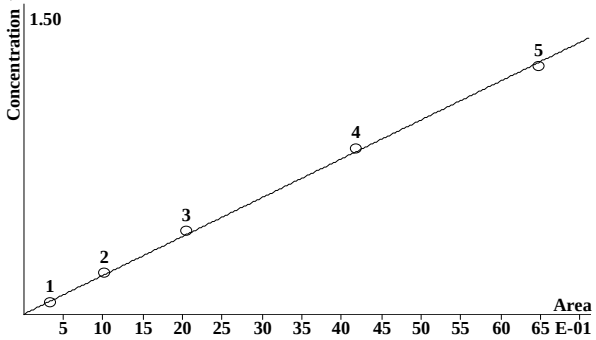

chloride: RSD: 0.05%
Q = - 7.96e-07·A^2 + 0.0428·A + 0.209



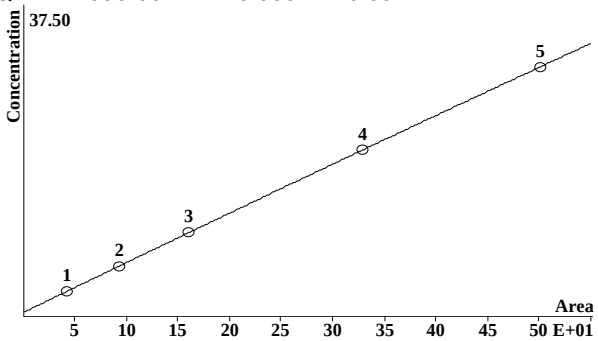

nitrate: RSD: 0.09%
Q = - 6.998e-06·A^2 + 0.078·A + 0.390



phosphate: RSD: 2.550 %, corr. coeff.: 0.99968
Q = 0.18538·A + 0.0105642

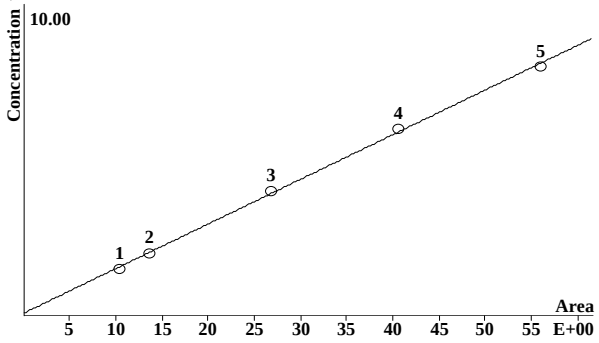



sulfate: RSD: 0.09%
Q = - 2.759e-06·A^2 + 0.060·A + 0.392

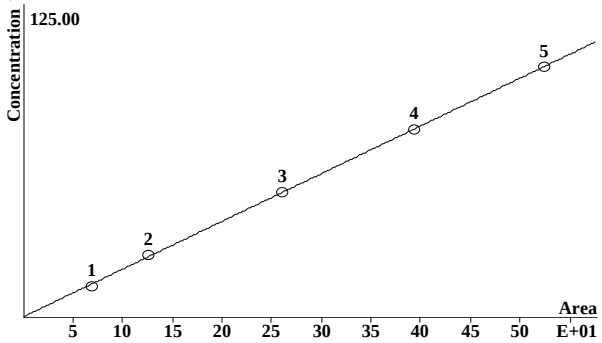



**Cations:**

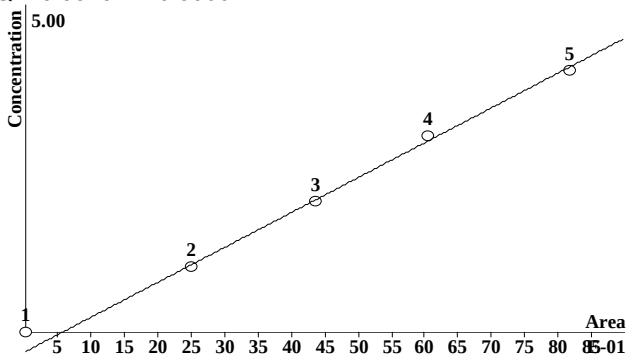
sodium: RSD: 2.38%
Q = 0.1434·A + 0.0674



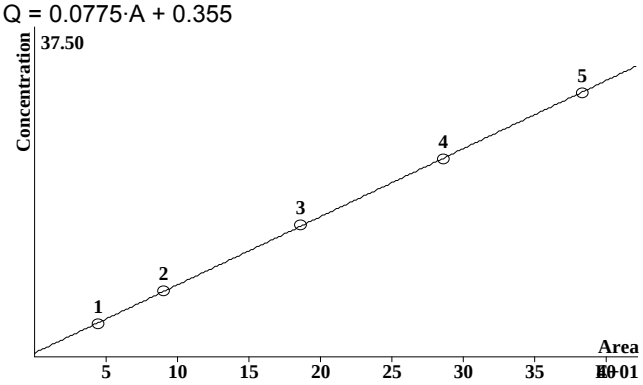

calcium: RSD: 1.30%
Q = 0.1903·A + 0.1929



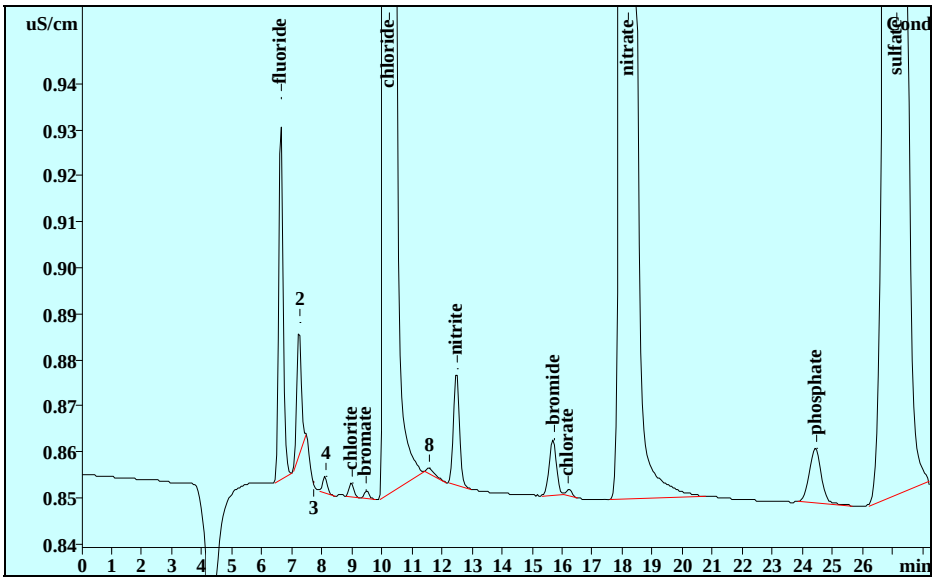

potassium: RSD: 2.77%
Q = 0.5325·A - 0.3066




magnesium: RSD: 0.87%
Q = 0.0775·A + 0.355



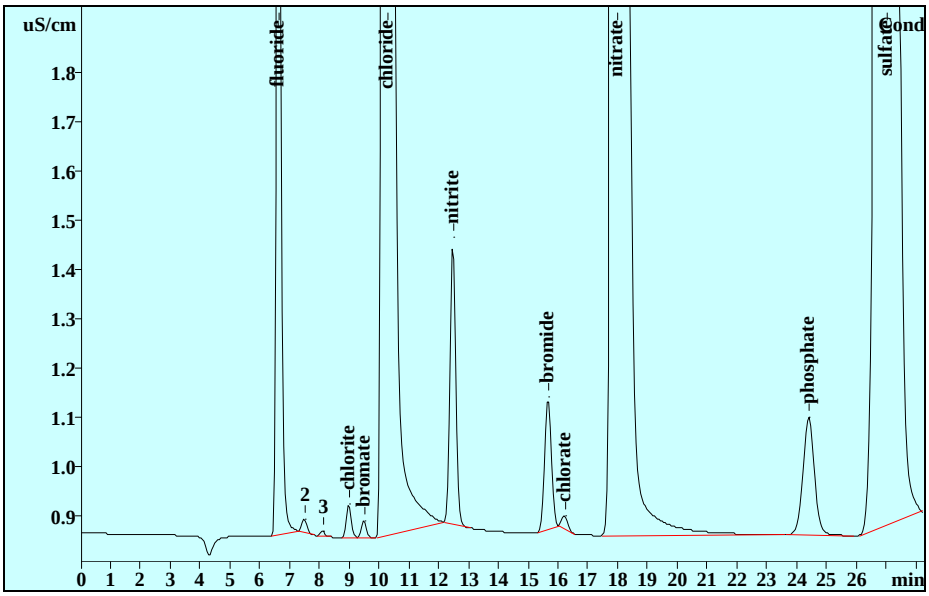
### *Chromatograms with peak tables - Anions*




Standard 1

| | |
|---|---|
| File | q3211205 |
| Volume: | 20.0 µl |
| Dilution: | 1.00 |
| Amount: | 1.00 |

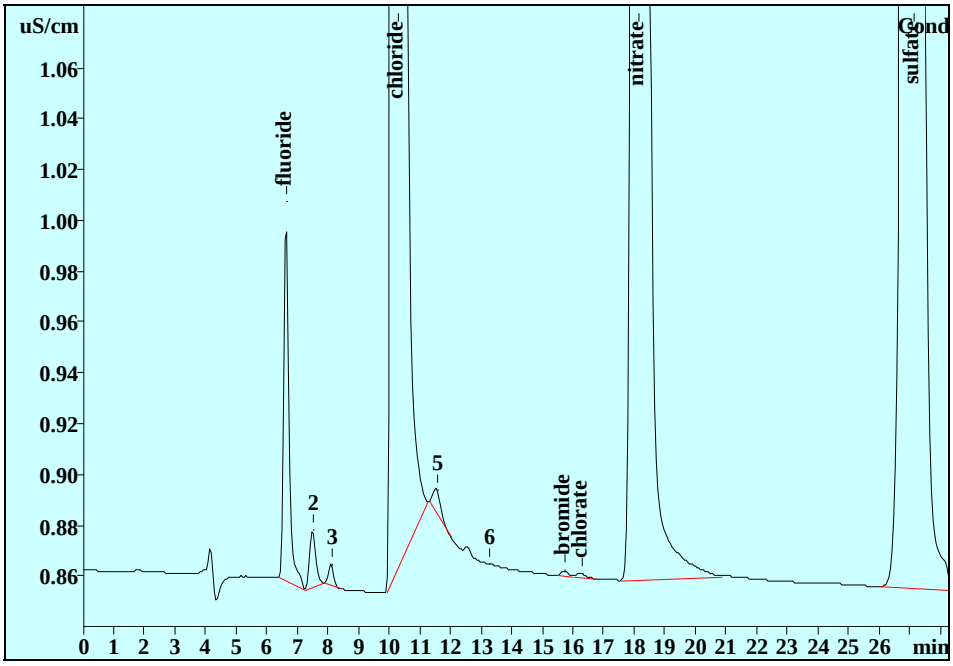
| No | Retention min | Height uS/cm | Area uS/cm*sec | Conc. mg/L | Name |
|---|---|---|---|---|---|
| 1 | 6.63 | 0.08 | 0.801 | 0.0309 | fluoride |
| 5 | 8.99 | 0.00 | 0.033 | 0.0050 | chlorite |
| 6 | 9.48 | 0.00 | 0.022 | 0.0050 | bromate |
| 7 | 10.24 | 5.92 | 65.089 | 2.9945 | chloride |
| 9 | 12.48 | 0.03 | 0.341 | 0.0291 | nitrite |
| 10 | 15.69 | 0.01 | 0.199 | 0.0295 | bromide |
| 11 | 16.21 | 0.00 | 0.018 | 0.0057 | chlorate |
| 12 | 18.17 | 1.77 | 33.358 | 3.0096 | nitrate |
| 13 | 24.43 | 0.01 | 0.336 | 0.0669 | phosphate |
| 14 | 27.11 | 1.59 | 43.355 | 3.0100 | sulfate |




Standard 5

| | |
|---|---|
| File | q3211105 |
| Volume: | 20.0 µl |
| Dilution: | 1.00 |
| Amount: | 1.00 |

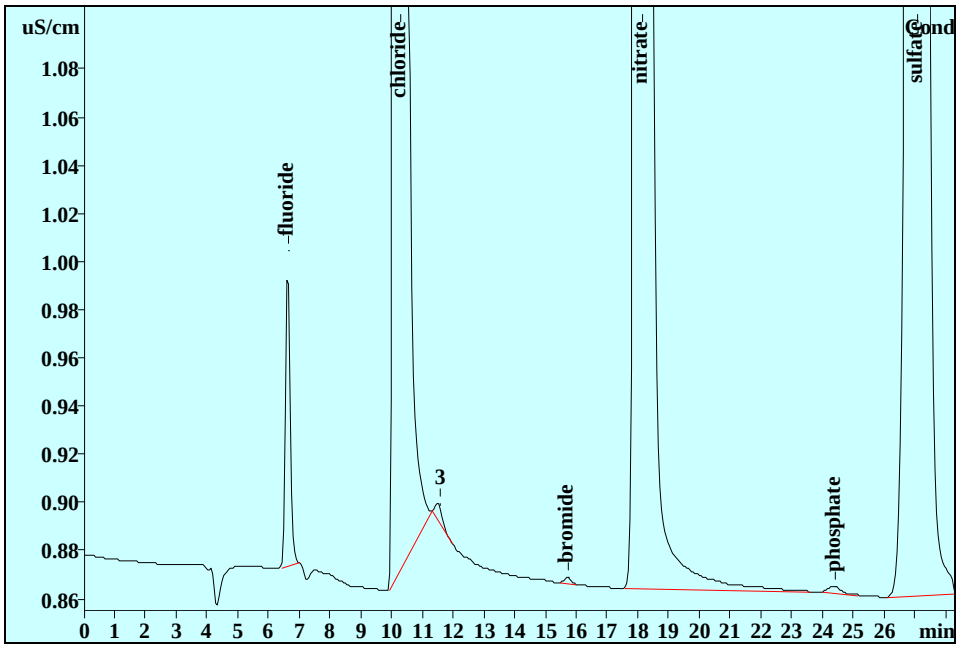
| No | Retention min | Height uS/cm | Area uS/cm*sec | Conc. mg/L | Name |
|---|---|---|---|---|---|
| 1 | 6.63 | 2.08 | 19.906 | 0.6001 | fluoride |
| 4 | 8.98 | 0.07 | 0.730 | 0.1000 | chlorite |
| 5 | 9.49 | 0.03 | 0.395 | 0.1000 | bromate |
| 6 | 10.29 | 58.94 | 704.574 | 30.0012 | chloride |
| 7 | 12.48 | 0.58 | 7.637 | 0.6002 | nitrite |
| 8 | 15.67 | 0.27 | 4.221 | 0.6005 | bromide |
| 9 | 16.22 | 0.03 | 0.378 | 0.0999 | chlorate |
| 10 | 17.98 | 18.67 | 389.425 | 29.9971 | nitrate |
| 11 | 24.41 | 0.24 | 6.477 | 1.2010 | phosphate |
| 12 | 26.99 | 17.81 | 500.850 | 29.9971 | sulfate |




Sample 1

| | |
|---|---|
| File | q3220119 |
| Volume: | 20.0 µl |
| Dilution: | 1.00 |
| Amount: | 1.00 |

| No | Retention min | Height uS/cm | Area uS/cm*sec | Conc. mg/L | Name |
|---|---|---|---|---|---|
| 1 | 6.63 | 0.15 | 1.743 | 0.0625 | fluoride |
| 4 | 10.26 | 23.94 | 303.280 | 13.1299 | chloride |
| 7 | 15.73 | 0.00 | 0.033 | 0.0048 | bromide |
| 8 | 16.27 | 0.00 | 0.031 | 0.0099 | chlorate |
| 9 | 18.14 | 6.58 | 125.507 | 10.1635 | nitrate |
| 10 | 27.11 | 2.99 | 82.005 | 5.3346 | sulfate |

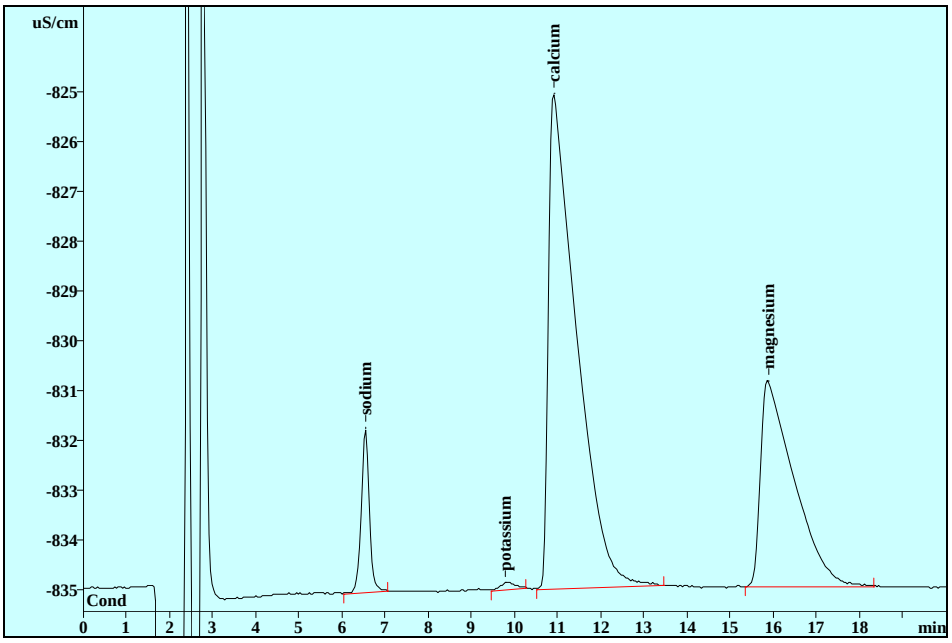



Sample 2

| | |
|---|---|
| File: | q3221750 |
| Volume: | 20.0 µl |
| Dilution: | 1.00 |
| Amount: | 1.00 |

| No | Retention min | Height uS/cm | Area uS/cm*sec | Conc. mg/L | Name |
|---|---|---|---|---|---|
| 1 | 6.62 | 0.13 | 1.339 | 0.0490 | fluoride |
| 2 | 10.25 | 27.45 | 329.370 | 14.2346 | chloride |
| 3 | 11.76 | 0.01 | 0.089 | 0.0000 | |
| 4 | 15.72 | 0.00 | 0.042 | 0.0054 | bromide |
| 5 | 18.12 | 6.39 | 122.016 | 9.8952 | nitrate |
| 6 | 24.39 | 0.00 | 0.079 | 0.0092 | phosphate |
| 7 | 27.09 | 3.23 | 88.351 | 5.7155 | sulfate |

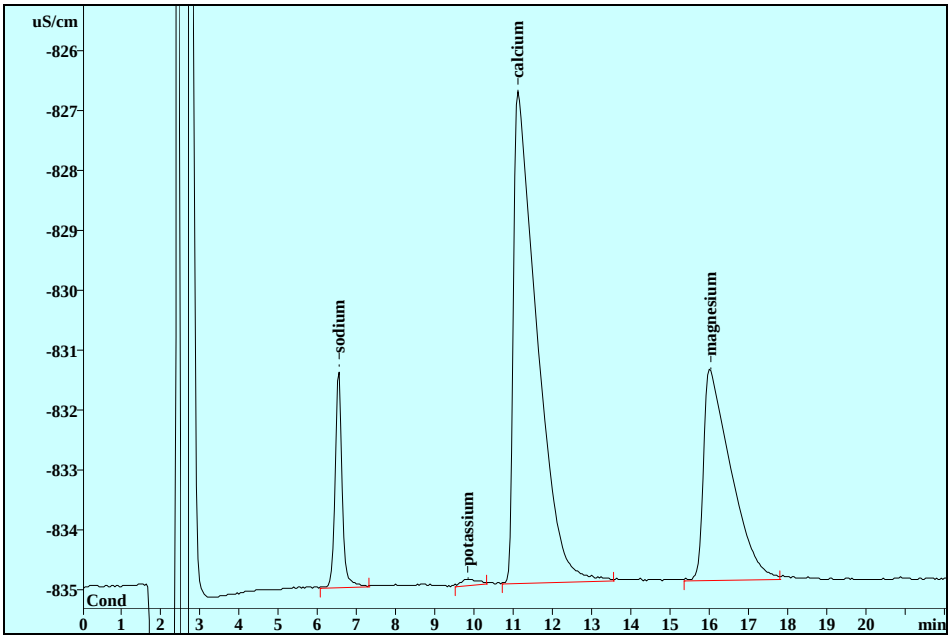
***Cations:***




Sample 1

| | |
|---|---|
| File: | q3220120 |
| Volume: | 10.0 µl |
| Dilution: | 1.00 |
| Amount: | 1.00 |

| No | Retention min | Height uS/cm | Area uS/cm*sec | Conc. mg/L | Name |
|---|---|---|---|---|---|
| 1 | 6.56 | 3.31 | 42.731 | 6.1884 | sodium |
| 2 | 9.79 | 0.14 | 3.155 | 1.5719 | potassium |
| 3 | 10.92 | 9.97 | 450.169 | 85.2894 | calcium |
| 4 | 15.86 | 4.16 | 225.558 | 17.7705 | magnesium |




Sample 2

| | |
|---|---|
| File: | q3221751 |
| Volume: | 10.0 µl |
| Dilution: | 1.00 |
| Amount: | 1.00 |

| No | Retention min | Height uS/cm | Area uS/cm*sec | Conc. mg/L | Name |
|---|---|---|---|---|---|
| 1 | 6.53 | 3.73 | 45.260 | 6.5590 | sodium |
| 2 | 9.79 | 0.11 | 3.002 | 1.2923 | potassium |
| 3 | 11.10 | 8.24 | 341.400 | 65.1877 | calcium |
| 4 | 15.98 | 3.54 | 170.864 | 13.5999 | magnesium |

***Titration curves – Titration of m-value (to pH 4.3)***

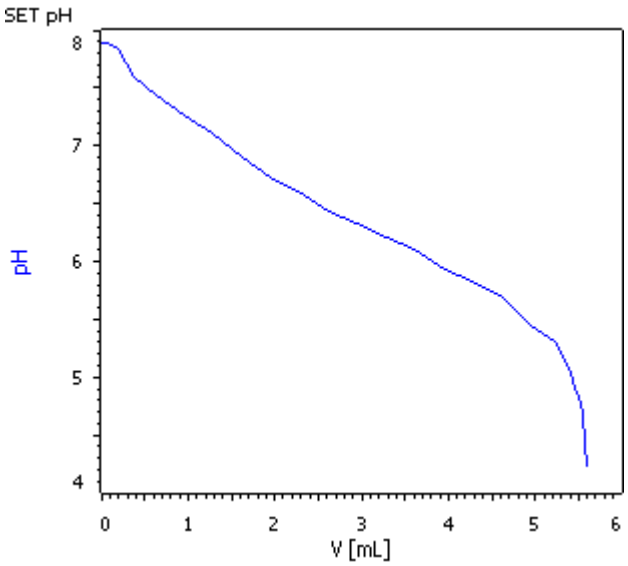



***Fig. 1:*** *SET pH of Sample 1*

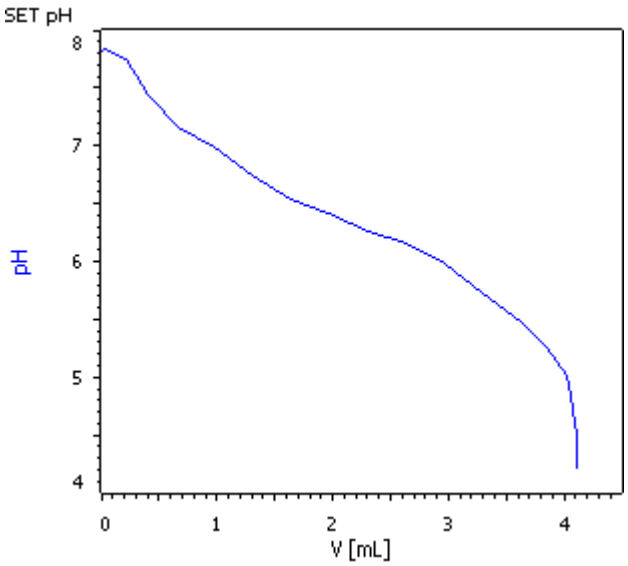



***Fig. 2:*** *SET pH of Sample 2*