

GLOBE QA/QC

Alkalinity

The Kits:

LaMotte

- Tests total alkalinity using bromcresol green-methyl red tableted indicator and a 0.1% sulfuric acid solution titrant.
- Endpoint is described as pink.
- One drop from the titrator syringe corresponds to a change of 8 ppm.

Potential Problems:

- The endpoint of the titration is subjective. Before a vivid pink is reached, the indicator turns a purple color that sometimes appears pink and sometimes does not.
- It is a little difficult to fill the 5-mL sample beaker precisely.

HACH

- Tests alkalinity using a phenolphthalein and a bromcresol green-methyl red indicators and a 0.035 N sulfuric acid solution titrant.
- Has both a high-range and a low-range test.
- Indicator changes from pink to clear at endpoint.
- Alkalinity is computed by multiplying the number of titrant drops added by 20.

Potential Problems:

- Precision cannot be greater than ± 20 ppm.

Hanna

- Tests total alkalinity using a bromphenol blue indicator solution and a 0.1% hydrochloric acid solution titrant.
- Has both a high-range and a low-range test.
- Indicator goes from blue-green to yellow at endpoint.
- Each drop from the titrator corresponds to a change of 12 ppm for the high-range test, and 4 ppm for the low range test.

Potential Problems:

- The indicator turns bluish-yellow before turning unmistakably yellow at the endpoint, making it hard to accurately determine the endpoint by color.
- There is some difficulty in measuring 5 mL of sample to be tested.

QA/QC Testing:

Kit Testing

Three alkalinity kits models, HACH #24442-22, Hanna HI3811, and LaMotte Model WAT-DR, were tested using the instructions provided in each kit. Three HACH kits, five Hanna kits, and five LaMotte kits were each tested ten times. A LaMotte alkalinity standard of 130 ppm as CaCO₃ was used for the tests. The high-range test method was used for the Hanna kit.

Results:

HACH Kits

| | Kit A | Kit B | Kit C | All Kits |
|-----------------|-------|-------|-------|----------|
| Mean (ppm) | 196 | 179 | 186 | 186 |
| Std. Dev. (ppm) | 8.4 | 12.6 | 9.7 | 13.0 |
| Range (ppm) | 20 | 40 | 20 | 40 |
| Percent Error | 51% | 35% | 43% | 43% |

Hanna Kits

| | Kit A | Kit B | Kit C | Kit D | Kit E | All Kits |
|-----------------|-------|-------|-------|-------|-------|----------|
| Mean (ppm) | 151.2 | 151.5 | 156.3 | 157.2 | 163.5 | 155.9 |
| Std. Dev. (ppm) | 6.8 | 6.0 | 8.2 | 9.3 | 7.1 | 8.6 |
| Range (ppm) | 21 | 21 | 24 | 27 | 21 | 36 |
| Percent Error | 16% | 17% | 20% | 21% | 26% | 20% |

LaMotte Kits

| | Kit A | Kit B | Kit C | Kit D | Kit E | All Kits |
|-----------------|-------|-------|-------|-------|-------|----------|
| Mean (ppm) | 145.7 | 143.8 | 138.1 | 129.3 | 143.2 | 140.5 |
| Std. Dev. (ppm) | 5.7 | 3.0 | 7.5 | 4.7 | 4.9 | 8.2 |
| Range (ppm) | 20 | 8 | 26 | 12 | 16 | 34 |
| Percent Error | 12% | 11% | 6% | <1% | 12% | 8% |

Conclusions:

The HACH kits have the largest percent error and the least accuracy based on the size of the titrant drop added to the solution. The Hanna kit is slightly more accurate, but still outside the acceptable range of error of plus or minus one drop, which in this case would be ± 12 ppm. The LaMotte kits produced the best results. Although some kits are outside the range of plus or minus one drop, other kits were within that range, which for the LaMotte kits is ± 8 ppm.

Low-Range Test

The Hanna kits were re-tested using the low-range test method. The low-range test differs from the high-range test only in the amount of sample used to determine alkalinity and in the multiplying factor used to determine alkalinity from the titrator scale. Two separate tests were conducted, one using a 79 mg/L as CaCO₃ standard, and another using a 160 mg/L as CaCO₃ standard.

Results:

Hanna Low-Range Test, 79 mg/L as CaCO₃

| | Kit A | Kit B | Kit C | Kit D | Kit E | All Kits |
|-----------------|-------|-------|-------|-------|-------|----------|
| Mean (ppm) | 89.50 | 91.00 | 95.40 | 95.60 | 97.60 | 93.82 |
| Std. Dev. (ppm) | 2.55 | 3.46 | 2.72 | 1.96 | 2.55 | 4.02 |
| Range (ppm) | 8 | 11 | 9 | 5 | 7 | 13 |
| Percent Error | 13.3% | 15.2% | 20.8% | 21.0% | 23.5% | 18.8% |

Hanna Low-Range Test, 160 mg/L as CaCO₃

| | Kit A | Kit B | Kit C | Kit D | Kit E | All Kits |
|-----------------|-------|-------|-------|-------|-------|----------|
| Mean (ppm) | 174.8 | 173.0 | 180.3 | 183.6 | 190.9 | 180.5 |
| Std. Dev. (ppm) | 5.07 | 5.81 | 5.54 | 3.60 | 3.93 | 8.00 |
| Range (ppm) | 18 | 16 | 16 | 12 | 12 | 33 |
| Percent Error | 9.3% | 8.1% | 12.7% | 14.8% | 19.3% | 12.8% |

Conclusions:

The results show that the low-range test offered greater accuracy for the 160 mg/L standard than was achieved using the high-range test and the 130 mg/L standard. Improvement was seen for all five kits, with improvements ranging from 8.0% to 10.3%. The variance among measurement values was also lower using the low-range test.

Accuracy for the low-range test using the 79 mg/L standard was very close to that obtained with the high-range test and the 130 mg/L standard, although all five kits showed slightly improved accuracy. Improvements ranged from 1.3% to 4.8%.

Standard Testing

Alkalinity standards were tested for accuracy using a HACH digital titrator, pre-loaded with 0.16 N H₂SO₄, and a pH electrode with ATC. The standards were titrated down to a pH below 3.5, and a Gran function plot was made for each test following USGS guidelines. The Gran function plot determines the volume of titrant at which the titration has reached its endpoint. Based on this volume of titrant the concentration of the alkalinity standard can be calculated.

Results:

| Theoretical Value (mg/L as CaCO ₃) | Measured Value (mg/L as CaCO ₃) |
|---|--|
| 81 | 79 |
| 130 | 128 |
| 163 | 160 |

Conclusions:

All three standards are accurate, and the LaMotte standard of 130 mg/L falls within the range of ± 2 mg/L given by the company.

Titrant Concentration Tests

A test was conducted on the titrants provided in three alkalinity kits: one HACH kit, one Hanna kit, and one LaMotte kit. The titrants were measured using the 79 mg/L standard made previously. For the titrations a class A glass buret capable of delivering titrant in 0.05 mL increments was used. A calibrated pH probe with ATC was used to monitor the titrations. Gran function plots were generated for each titration so that the volume of titrant consumed at the endpoint could be determined. Using this volume the normality of the titrant could be determined.

Results:

HACH

| | |
|-----------------------|---|
| Stated Normality: | 0.035 (H ₂ SO ₄) |
| Measured Normality 1: | 0.031 |
| Measured Normality 2: | 0.029 |
| Average Normality: | 0.030 |
| Error: | 14.3% |

Hanna

| | |
|-----------------------|------------------|
| Stated Normality: | 0.027 (0.1% HCl) |
| Measured Normality 1: | 0.026 |
| Measured Normality 2: | 0.023 |
| Average Normality: | 0.025 |
| Error: | 7.4% |

LaMotte

| | |
|-----------------------|--|
| Stated Normality: | 0.020 (0.1% H ₂ SO ₄) |
| Measured Normality 1: | 0.017 |
| Measured Normality 2: | 0.019 |
| Average Normality: | 0.018 |
| Error: | 10.0% |

Conclusions:

The actual concentrations of the titrants are lower than advertised in the kits. A lower titrant concentration will lead to a higher measured alkalinity value. It is possible that the inaccurate titrant concentrations are causing the high alkalinity values observed during the kit testing.

Recommendations

For most of the QA/QC testing that was done on the alkalinity kits the LaMotte kits seemed to produce the best results. Therefore, it would be advisable for students to use this kit.

Dissolved Oxygen

The Kits:

LaMotte

- Water is sampled by submerging the bottle and letting water flood in.
- The sample is fixed by adding drops of manganous sulfate, alkaline potassium iodide azide, and sulfamic acid powder.
- The solution is titrated with sodium thiosulfate until the blue color of the starch indicator disappears.
- Each drop of the titrator corresponds to 0.4 ppm dissolved oxygen.

Potential Problems:

- It is difficult to measure and add the sulfamic acid powder to the sample.

HACH

- Water is collected by allowing water to flow over the bottle for a few minutes.
- The sample is fixed by adding the powdered contents of three separate reagents in order to the sample.
- The fixed sample is titrated with a sodium thiosulfate solution until the solution changes from yellow to colorless.
- Each from the titrator corresponds to 1.0 mg/L of dissolved oxygen.

Potential Problems:

- The powder from the reagent packets will often not break the surface tension of the sample water and will be forced out when the stopper is replaced.

Hanna

- Water is sampled by pouring water into the sample bottle and allowing it to overflow.
- The analysis is an azide modification titration.
- All the reagents added to the sample water are liquid and are measured by drop.
- The solution is titrated with sodium thiosulfate until the system changes from the blue of the starch indicator to colorless.
- Each drop from the titrator corresponds to 0.4 ppm dissolved oxygen for the high range test, and 0.2 ppm dissolved oxygen for the low range test.

Potential Problems:

- Sampling bottle may sometimes trap bubbles, invalidating the test.

QA/QC Testing:

Sampling Method

A discussion arose as to whether the technique by which students sample water in the dissolved oxygen bottle can bias the test. The two techniques in question involve submerging the bottle and letting the water flood in and pouring water into the bottle to fill it. These two techniques were tested to determine which one was more reliable.

Water Pouring Test:

The percent oxygen in the sample water was measured using a microprobe. Water was poured into one of three dissolved oxygen sample bottles: one from Hanna, one from LaMotte, and one from HACH. Dissolved oxygen was measured in the sample water at concentrations of 3, 2, 1, and below 1 mg/L using the chemicals from a Hanna DO kit.

Submerged Bottle Test:

The percent oxygen in the sample water was measured using a microprobe. A sealed dissolved oxygen bottle was submerged in the water. The bottle was opened and water was allowed to flood in. Dissolved oxygen was measured in the sample water at concentrations of 3, 2, 1, and below 1 mg/L using the chemicals from a Hanna DO kit.

Results:

| Technique | Kit | Mean difference between measured DO value and calculated DO value (mg/L) | Standard Deviation |
|------------------|---------|--|--------------------|
| Pouring Water | Hanna | 0.15 | 0.084 |
| | LaMotte | 0.17 | 0.16 |
| | HACH | 0.23 | 0.21 |
| Submerged Bottle | Hanna | 0.082 | 0.086 |
| | LaMotte | 0.18 | 0.10 |

| | | |
|------|------|-------|
| HACH | 0.12 | 0.064 |
|------|------|-------|

Conclusions:

Submerging the DO bottle and letting the water flood in is a more reliable technique to collect water for measuring dissolved oxygen.

Kit Testing

The oxygen level in the sample water was controlled by bubbling a mixture of air and nitrogen in the water. The percent oxygen in the sample water was measured using a microprobe. Water was then poured into a sample bottle and DO was measured using the chemicals from that kit. Values were measured around 5 mg/L. One kit each from Hanna, LaMotte, and HACH was tested.

Results:

| Kit | Mean difference between measured DO value and calculated DO value (mg/L) | Standard Deviation |
|---------|--|--------------------|
| Hanna | 0.25 | 0.26 |
| LaMotte | 0.79 | 0.077 |
| HACH | 0.57 | 0.26 |

Conclusions:

The Hanna kit produced the most accurate results and is within the limits of plus or minus one drop, which for the Hanna kit corresponds to 0.4 mg/L. The LaMotte kit is not within these acceptable parameters, which for the LaMotte kit is also 0.4 mg/L. However, the LaMotte kit produced the most precise results and was consistently off by the same amount. The HACH kit, although it produced poor results, is still within the range of plus or minus one drop, which for the HACH kit corresponds to a change of 1.0 mg/L.

Recommendations:

GLOBE should recommend the use of the Hanna DO kit both because of the accuracy of the results it produced, but also because of its ease of use. Also, GLOBE should recommend that students sample water in a DO bottle by submerging the bottle in the sample water and letting water flood in.

Nitrate

The Kits:

LaMotte Nitrate-Nitrogen Test Kit, Model NCR-2

- This is a cadmium-based nitrate reducing kit.
- The test takes approximately 15 minutes to run.
- The nitrate reducing reagent is added as a powder measured out with a spoon.
- The comparator ranges from 0.25 to 10.0 ppm nitrate-nitrogen.

Potential Problems:

- The reducing reagent is a powder that can easily be spread.
- Measuring the correct amount of reagent powder with the provided spoon is difficult.
- Often the obtained colors did not match with the color comparator.

LaMotte Nitrate-Nitrogen Tablet Kit

- This is a zinc-based nitrate reducing kit.
- The test takes about 5 minutes to run.
- All reagents are added as tablets.
- The comparator ranges from 0 to 15 ppm nitrate-nitrogen.

Potential Problems:

- May not be accurate for a low-range test.

HACH Model NI-11

- This is a cadmium-based nitrate reducing kit.
- The test takes only a few minutes to run.
- There is only one reagent to add from a powder pillow.
- The comparator ranges from 0 to 50 ppm nitrate-nitrogen.

Potential Problems:

- May not be accurate for the low-range test.

HACH Model NI-14

- This is not a cadmium-based test kit.
- This test takes about 15 minutes to run.
- There are two reagents to add from a powder pillows.
- The kit has a high range test for measuring 0 to 10 ppm nitrate-nitrogen, and a low range test for measuring 0 to 1 ppm nitrate-nitrogen.

Potential Problems:

- It can be difficult to match obtained colors with colors on the color wheel because the color gradient on the wheel is low.

Visocolor

- This is a German nitrate test kit.
- It does not indicate whether or not cadmium is used.
- The test only takes a few minutes to run.
- Two reagents are added, both as a liquid.
- The comparator ranges from 1 to 50 ppm nitrate-nitrogen.

Potential Problems:

- The comparator ranges from 1 to 50 ppm nitrate-nitrogen but only has six colors on it with which to compare.

QA/QC Testing:

Kit Testing

In order to determine the accuracy of the kits the available nitrate kits were each tested ten times with a nitrate standard of known concentration. High-range and low-range tests were used where appropriate.

Results:

Kits tested using a 10 ppm nitrate-nitrogen standard

| Kit | LaMotte Test | LaMotte Tablet | HACH Model | HACH Model |
|-----|--------------|----------------|------------|------------|
|-----|--------------|----------------|------------|------------|

| | Kit | Kit | NI-11 | NI-11 |
|--------------------------|------|------|-------|-------|
| Mean (ppm) | 9.7 | 9.2 | 8.7 | 8.6 |
| Standard Deviation (ppm) | 1.06 | 0.63 | 0.95 | 0.70 |
| Range (ppm) | 3.0 | 2.0 | 3.0 | 2.0 |
| Percent Error | 3% | 8% | 13% | 14% |

Kits tested using a 0.32 ppm nitrate-nitrogen standard

| Kit | HACH Model NI-14 | HACH Model NI-14 | HACH Model NI-14 | HACH Model NI-14 |
|--------------------------|---------------------|---------------------|---------------------|---------------------|
| Mean (ppm) | 0.32 | 0.31 | 0.32 | 0.31 |
| Standard Deviation (ppm) | 0.027 | 0.057 | 0.031 | 0.053 |
| Range (ppm) | 0.1 | 0.16 | 0.1 | 0.16 |
| Percent Error | 0% | 3% | 0% | 3% |

Conclusions:

All of these kits produced accurate and precise results for obtaining nitrate values. For the high-range tests the LaMotte kits proved to have less error and were more reliable. However, natural waters tend to have nitrate values lower than 1.0 ppm. Therefore, for more practical use the HACH model NI-14 proved to be superior because it has both a high- and low-range test.

Un-Biased Test

While the four HACH Model NI-14 kits were tested, the tester knew what value the kit should produce. It was believed that the tester biased the results when comparing colors on the comparator. Therefore, the test was run again using a group of tester. Two tests were run using a HACH Model NI-14 nitrate kit. Each time a group of people was given the end result and told to read the value off the color comparator. At no time during the experiment were the testers allowed to know what value the result should be.

Results:

Un-biased nitrate test using a 0.32 ppm nitrate-nitrogen standard

| Kit | HACH Model NI-14 | HACH Model NI-14 |
|--------------------------|------------------|------------------|
| Mean (ppm) | 0.30 | 0.27 |
| Standard Deviation (ppm) | 0.017 | 0.036 |
| Range (ppm) | 0.04 | 0.10 |
| Percent Error | 6% | 16% |

Conclusions:

Eliminating any potential bias in the test only slightly affected the results. Having a number of different people read the nitrate value off the comparator can also reduce some error in the testing due to differing eye-sight.

Visocolor Test

Only a few tests were run using this kit. Each time a 20 ppm nitrate-nitrogen standard was used. Each time the kit produced a result right around this value. However, the only values on the color comparator are 1, 2, 5, 10, 20, and 50 ppm. Therefore, there can be quite a bit of error if you sample color does not match with the comparator and you have to estimate between two colors.

Recommendation:

HACH model NI-14 proved to be the superior test kit due to its versatility and its accuracy. The kit also does not use cadmium, which makes it ideal for any teachers worried about any potential health problems associated with cadmium.

pH

The Equipment

Orion pH Meter

- Requires a three point calibration with buffers of 4.0, 7.0, and 10.0.

Potential Problems:

- Values may drift over time.

HACH pH Pens

- Require a one-point calibration with a buffer of 7.0.

Potential Problems:

- Values may drift over time.
- Only useful for pH values around 7.0.

QA/QC Testing:

Conductivity Test

The way the pH meters and pens work makes them inaccurate at low conductivity levels. To test at what conductivity limit they become inaccurate the conductivity of a beaker of de-ionized water was gradually raised and the pH was measured using four Orion pH meters, five HACH pH pens, and a Fisher ATC pH probe.

Results:

Trial 1 pH versus conductivity (reported values are pH)

| Conductivity (? S/cm) | Fisher | Orion A | Orion B | Orion C | Orion F | HACH A | HACH B | HACH C | HACH D | HACH E |
|--------------------------|--------|------------|------------|------------|------------|-----------|-----------|-----------|-----------|-----------|
| 51.4 | 6.8 | 7.4 | 7.4 | 7.5 | 7.7 | 8.6 | 6.9 | 6.9 | 6.9 | 7.2 |
| 68.4 | 6.7 | 7.0 | 6.9 | 7.1 | 7.0 | 8.4 | 6.5 | 6.5 | 6.7 | 6.7 |
| 84.2 | 6.8 | 6.9 | 6.9 | 6.9 | 6.9 | 8.3 | 6.5 | 6.5 | 6.7 | 6.5 |
| 100.7 | 6.8 | 6.9 | 6.9 | 6.9 | 6.9 | 8.3 | 6.5 | 6.5 | 6.5 | 6.7 |
| 121.9 | 6.8 | 6.9 | 6.9 | 6.9 | 6.9 | 8.1 | 6.5 | 6.5 | 6.9 | 6.7 |
| 173.5 | 6.7 | 6.8 | 6.8 | 6.8 | 6.9 | 8.2 | 6.5 | 6.5 | 6.8 | 6.5 |
| 219 | 6.8 | 6.8 | 6.9 | 6.8 | 6.9 | 8.1 | 6.5 | 6.5 | 6.7 | 6.5 |
| 277 | 6.8 | 6.9 | 6.9 | 6.9 | 6.9 | 8.1 | 6.6 | 6.6 | 6.7 | 6.8 |
| 309 | 6.8 | 6.9 | 6.9 | 6.9 | 6.9 | 8.0 | 6.6 | 6.6 | 6.7 | 6.6 |

Trial 2 pH versus conductivity (reported values are pH)

| Conductivity (? S/cm) | Fisher | Orion A | Orion B | Orion C | Orion F | HACH A | HACH B | HACH C | HACH D | HACH E |
|--------------------------|--------|------------|------------|------------|------------|-----------|-----------|-----------|-----------|-----------|
| 10.9 | 7.4 | 7.6 | 7.7 | 7.7 | 7.6 | 8.8 | 7.1 | 6.7 | 7.0 | 7.1 |
| 20.9 | 7.2 | 7.2 | 7.3 | 7.3 | 7.3 | 8.5 | 6.8 | 6.7 | 6.9 | 6.8 |
| 36.3 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 8.4 | 6.7 | 6.7 | 6.8 | 6.8 |
| 46.9 | 7.1 | 7.1 | 7.2 | 7.1 | 7.2 | 8.3 | 6.7 | 6.7 | 6.9 | 6.7 |
| 57.8 | 7.1 | 7.1 | 7.2 | 7.2 | 7.2 | 8.3 | 6.7 | 6.7 | 6.9 | 6.7 |
| 72.0 | 7.1 | 7.1 | 7.2 | 7.1 | 7.2 | 8.2 | 6.7 | 6.7 | 6.9 | 6.7 |

| | | | | | | | | | | |
|--------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 90.2 | 7.0 | 7.1 | 7.2 | 7.1 | 7.2 | 8.1 | 6.7 | 6.7 | 6.8 | 6.7 |
| 104.1 | 7.0 | 7.0 | 7.1 | 7.2 | 7.2 | 8.1 | 6.7 | 6.7 | 6.8 | 6.7 |
| 124.8 | 7.0 | 7.0 | 7.1 | 7.1 | 7.1 | 8.0 | 6.7 | 6.7 | 6.8 | 6.7 |
| 192.2 | 7.0 | 6.9 | 7.0 | 7.0 | 7.1 | 7.9 | 6.7 | 6.7 | 6.8 | 6.7 |
| 518 | 6.9 | 6.9 | 7.0 | 6.9 | 7.0 | 7.6 | 6.6 | 6.7 | 6.8 | 6.7 |

Conclusion:

The above data shows that both the Orion pH meters and the HACH pH pens are inaccurate at low conductivity levels. The acceptable error in the pH meters and pens is plus or minus 0.1 pH units. The Orion meters reach this acceptable limit fairly quickly, whereas the HACH pens do not. According to this data, the proposed low-end for pH meter accuracy of 100 μ S/cm is valid.

Meter Ranges:

The pH meters and pens were tested to determine their accuracy and high and low end pH values. Four Orion pH meters, four HACH pH pens, and one Fisher ATC pH probe were used in the test.

Results:

pH Ranges

| Fisher pH | Orion A | Orion B | Orion C | Orion F | HACH A | HACH B | HACH C | HACH D | HACH E |
|--------------|------------|------------|------------|------------|-----------|-----------|-----------|-----------|-----------|
| 9.2 | 9.2 | 9.2 | 9.2 | 9.4 | 7.7 | 9.1 | 8.8 | 8.6 | 8.8 |
| 4.5 | 4.4 | 4.4 | 4.4 | 4.4 | 5.5 | 4.4 | 4.6 | 4.6 | 4.5 |
| 9.3 | 9.4 | 9.4 | 9.3 | 9.5 | 8.8 | 9.0 | 9.3 | 9.1 | 9.2 |
| 4.5 | 4.4 | 4.5 | 4.5 | 4.5 | 5.0 | 4.3 | 4.6 | 4.7 | 4.4 |
| 9.3 | 9.3 | 9.3 | 9.2 | 9.4 | 8.8 | 8.8 | 8.2 | 8.9 | 9.1 |
| 4.4 | 4.4 | 4.5 | 4.5 | 4.5 | 4.6 | 4.3 | 4.6 | 4.7 | 4.4 |

Conclusions:

The above data shows that the Orion pH meters are more accurate at low- and high-range pH values. Because the HACH pH pen is only calibrated using a single point it should be expected that they are not be as accurate at these pH values.

Drift Test

After the above tests were completed the meters and pens were then used to determine the pH of the original buffer solutions in which they were calibrated.

Results:

| Fisher pH | Orion A | Orion B | Orion C | Orion F | HACH A | HACH B | HACH C | HACH D | HACH E |
|----------------------|--------------------|--------------------|--------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| 4.0 | 4.1 | 4.1 | 4.1 | 4.0 | | | | | |
| 7.0 | 7.1 | 7.0 | 7.0 | 6.9 | 6.7 | 6.8 | 7.1 | 7.0 | 7.0 |
| 10.0 | 10.1 | 10.0 | 10.0 | 10.2 | | | | | |

Conclusions:

The Orion pH pens, after a day of use, drift less than the HACH pH pens. Based on these results it should be recommended that pH meters and pens be calibrated every day they are used.

Recommendations:

Based on the above QA/QC tests it has been determined that the Orion pH meters are preferable to the HACH pH pens. Because they have a three-point calibration they are more accurate in measuring pH values between 4.0 and 10.0. As well, they drift less, making them more accurate even after extended use. However, neither brand is accurate at low conductivity levels and neither should be recommended for use at conductivity levels below 100 μ S/cm.

Salinity

The Equipment:

LaMotte Salinity Titration Test Kit

- Tests salinity by titrating with liquid reagents.
- Reagents are easy to add and measure.
- The test is fairly quick and easy to run.

Potential Problems:

- The color change of the titration is often subtle and it is difficult to determine the actual end point

- The reagents used are hazardous substances.

Hanna Salinity Test Kit

- Tests salinity by titrating with liquid reagents.
- Reagents are easy to measure.
- The color change at the titration endpoint is obvious.

Potential Problems:

- The reagents are difficult to add.
- The test takes practice to master.
- The titration syringe sticks easily.
- The test uses reagents that are highly toxic and corrosive.

Bellwether Hydrometer

Trophic Martin High Precision Hydrometer

QA/QC Testing:

Kit Testing

Salinity titration were conducted using both the Hanna and the LaMotte salinity test kits. Two Hanna kits and five LaMotte kits were used. Eleven titrations were run at a concentration of 35 ppt, and, due to lack of chemicals, only five titrations were run at 15 ppt.

Results:

35 ppt

| Kit | Hanna 1 | Hanna 2 | LaMotte 1 | LaMotte 2 | LaMotte 3 | LaMotte 4 | LaMotte 5 |
|--------------------|------------|------------|--------------|--------------|--------------|--------------|--------------|
| Mean (ppt) | 38.6 | 39.1 | 39.8 | 38.3 | 37.6 | 36.4 | 35.7 |
| Std. Dev. (ppt) | 0.60 | 0.30 | 2.36 | 3.51 | 2.15 | 0.64 | 0.76 |

15 ppt

| Kit | Hanna 1 | Hanna 2 | LaMotte 1 | LaMotte 2 | LaMotte 3 | LaMotte 4 | LaMotte 5 |
|-----|------------|------------|--------------|--------------|--------------|--------------|--------------|
|-----|------------|------------|--------------|--------------|--------------|--------------|--------------|

| | | | | | | | |
|-----------------|------|------|------|------|------|------|------|
| Mean (ppt) | 17.9 | 17.9 | 18.6 | 18.9 | 18.4 | 17.9 | 18.6 |
| Std. Dev. (ppt) | 0.16 | 0.18 | 0.67 | 0.94 | 0.05 | 0.17 | 0.67 |

Conclusions:

Overall, it appears that the Hanna kits are just as accurate as the LaMotte kits at both salinity levels. However, the Hanna kits appear to be more precise than the LaMotte kits as seen by the lower standard deviations. The LaMotte kits appear to be more precise at lower salinity levels than at higher ones.

Kits versus Hydrometers

Salinity was measured at three levels, 15 ppt, 25 ppt, and 35 ppt, using both hydrometers and titration kits. Four Bellwether hydrometers, one Trophic Martin high precision hydrometer, and five LaMotte titration kits were used in the experiment. Salinity was measured ten times at each level with each hydrometer and each titration kit. The Trophic Martin hydrometer was only used at the 35 ppt level because values below this are not in the range of the hydrometer. For the LaMotte kits the expected salinities are 16.5 ppt, 27.5 ppt, and 38.6 ppt, after a temperature conversion was made.

Results:

15 ppt

| Hydrometer | 1 | 2 | 3 | 4 | All 4 |
|-----------------|------|------|------|------|-------|
| Mean (ppt) | 14.5 | 14.5 | 13.0 | 13.2 | 13.9 |
| Std. Dev. (ppt) | 0.0 | 0.0 | 0.41 | 0.0 | 0.72 |
| Range (ppt) | 0.0 | 0.0 | 1.3 | 0.0 | 2.6 |
| % Error | 3% | 3% | 13% | 12% | 7.3% |

25 ppt

| Hydrometer | 1 | 2 | 3 | 4 | All 4 |
|-----------------|------|------|------|------|-------|
| Mean (ppt) | 24.9 | 24.7 | 22.3 | 23.6 | 23.9 |
| Std. Dev. (ppt) | 0.55 | 0.41 | 0.72 | 0.55 | 1.20 |
| Range (ppt) | 1.3 | 1.3 | 1.5 | 1.3 | 4.1 |
| % Error | 0% | 1% | 11% | 6% | 4% |

35 ppt

| Hydrometer | 1 | 2 | 3 | 4 | Trophic Martin | All 5 |
|-----------------|------|------|------|------|----------------|-------|
| Mean (ppt) | 34.0 | 33.9 | 31.5 | 32.6 | 33.8 | 33.2 |
| Std. Dev. (ppt) | 0.50 | 0.41 | 0.55 | 0.41 | 0.0 | 1.1 |
| Range (ppt) | 1.3 | 1.3 | 1.3 | 1.3 | 0.0 | 2.6 |
| % Error | 3% | 3% | 10% | 7% | 3% | 3% |

16.5 ppt

| LaMotte Kit | 1 | 2 | 3 | 4 | 5 | All 5 |
|-----------------|------|------|------|------|------|-------|
| Mean (ppt) | 17.0 | 17.8 | 17.8 | 17.7 | 17.7 | 17.6 |
| Std. Dev. (ppt) | 0.17 | 0.18 | 0.26 | 0.14 | 0.10 | 0.40 |
| Range (ppt) | 0.4 | 0.4 | 0.8 | 0.2 | 0.4 | 1.2 |
| % Error | 3% | 8% | 8% | 7% | 7% | 7% |

27.5 ppt

| LaMotte Kit | 1 | 2 | 3 | 4 | 5 | All 5 |
|-----------------|------|------|------|------|------|-------|
| Mean (ppt) | 27.2 | 28.6 | 28.4 | 28.7 | 28.4 | 28.3 |
| Std. Dev. (ppt) | 0.30 | 0.20 | 0.20 | 0.10 | 0.30 | 0.60 |
| Range (ppt) | 1.2 | 0.4 | 0.8 | 0.2 | 1.2 | 2.6 |
| % Error | 1% | 4% | 3% | 4% | 3% | 3% |

38.6 ppt

| LaMotte Kit | 1 | 2 | 3 | 4 | 5 | All 5 |
|-----------------|------|------|------|------|------|-------|
| Mean (ppt) | 37.9 | 39.6 | 39.7 | 39.6 | 39.5 | 39.3 |
| Std. Dev. (ppt) | 0.29 | 0.74 | 0.20 | 0.33 | 0.25 | 0.80 |
| Range (ppt) | 1.0 | 2.0 | 0.6 | 1.2 | 0.8 | 2.6 |
| % Error | 2% | 3% | 3% | 3% | 2% | 2% |

Conclusion:

The hydrometers are more precise than the kits, showing little variation within each hydrometer. The kits, however, are more accurate. Overall, both the kits and the hydrometers are easy to use.

Recommendations:

If better accuracy is what is desired then the kits are the preferable method for testing salinity. However, if teachers are concerned about the chemicals that the kits use, then a hydrometer is an acceptable alternative for measuring salinity.