Ammonium Ion-Selective Electrode

(Order Code NH4-BTA)

The Vernier Ammonium Ion-Selective Electrode is used to measure the concentration of ammonium (NH_4^+) ions in aqueous samples.

Inventory of Items Included with the Ammonium ISE

- Ion-Selective Electrode, packed with a storage bottle
- 30 mL bottle of High Standard solution with SDS (100 mg/L NH_4^+ as N)
- 30 mL bottle of Low Standard solution with SDS (1 mg/L NH_4^+ as N)
- Short-Term ISE Soaking Bottle

Collecting Data with the Ammonium ISE

This sensor can be used with the following interfaces to collect data.

- Vernier LabQuest® 2 or original LabQuest as a standalone device or with a computer
- Vernier LabQuest Mini with a computer
- Vernier LabPro® with a computer or TI graphing calculator
- Vernier Go!®Link
- Vernier EasyLink®
- Vernier SensorDAQ®
- CBL 2™
- TI-Nspire™ Lab Cradle

Data-Collection Software

This sensor can be used with an interface and the following data-collection software.

- **Logger *Pro* 3** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, or Go! Link.
- **Logger Lite** This computer program is used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, or Go! Link.
- **LabQuest App** This program is used when LabQuest 2 or LabQuest is used as a standalone device.
- **DataQuest™ Software for TI-Nspire™** This calculator application for the TI-Nspire can be used with the EasyLink or TI-Nspire Lab Cradle.
- **EasyData App** This calculator application for the TI-83 Plus and TI-84 Plus can be used with CBL 2, LabPro, and Vernier EasyLink. We recommend version 2.4 or newer, which can be downloaded from the Vernier website, www.vernier.com/easy/easydata.html, and then transferred to the calculator. See the Vernier website, www.vernier.com/calc/software/index.html for more information on the App and Program Transfer Guidebook.
- **DataMate program** Use DataMate with LabPro or CBL 2 and TI-73, TI-83, TI-84, TI-86, TI-89, and Voyage 200 calculators. See the LabPro and CBL 2 Guidebooks for instructions on transferring DataMate to the calculator.
- **LabVIEW™** National Instruments LabVIEW™ software is a graphical programming language sold by National Instruments. It is used with SensorDAQ and can be used with a number of other Vernier interfaces. See www.vernier.com/labview for more information.

This sensor is equipped with circuitry that supports auto-ID. When used with LabQuest 2, LabQuest, LabQuest Mini, LabPro, Go! Link, SensorDAQ, TI-Nspire™ Lab Cradle, EasyLink, or CBL 2™, the data-collection software identifies the sensor and uses pre-defined parameters to configure an experiment appropriate to the recognized sensor.

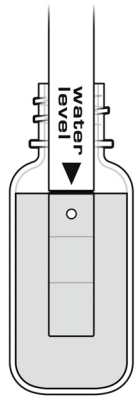
NOTE: Vernier products are designed for educational use. Our products are not designed nor are they recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

Preparing the Ammonium ISE for Use

Note: Follow this two-part process before taking measurements with your ISE.

Part I: Soak the Electrode

Soak the electrode in the High Standard solution (included with the ISE) for approximately 30 minutes. The ISE should not rest on the bottom of the container, and the small white reference contacts near the tip of the electrode should be immersed. Make sure no air bubbles are trapped below the ISE. **Important**: Do not leave the ISE soaking for more than 24 hours. **Important**: If you plan to use the electrode outside the range of the standards provided, you will need to prepare your own standards and use those for soaking.



Note: If the ISE needs to be transported to the field during the soaking process, use the Short-Term ISE Soaking Bottle. Remove the cap from the bottle and fill it 3/4 full with High Standard. Slide the bottle's cap onto the ISE, insert it into the bottle, and tighten.

For long term storage, greater than 24 hours, make sure the sensor is stored in its storage bottle with the sponge slightly damp.

Part II: Calibrate the ISE

Calibrating the Ammonium ISE with a computer

1. Connect the Ammonium ISE to an interface, and connect the interface to your computer. Open Logger *Pro* 3.
2. Choose Calibrate from the Experiment menu and then click Calibrate Now.
3. **High Standard Calibration Point:** The Ammonium ISE should still be soaking in the High Standard. The ISE should not rest on the bottom of the container, and

the small white reference contacts near the tip of the electrode should be immersed. Make sure no air bubbles are trapped below the ISE.

4. Enter the concentration value of the High Standard (e.g., **100** for 100 mg/L) in the edit box.
5. After the voltage reading for Reading 1 stabilizes (~2 minutes), click Keep.
6. **Low Standard Calibration Point:** Remove the ISE from the High Standard, rinse well with distilled water, and gently blot the ISE dry with a paper towel. Place the ISE into the Low Standard. Make sure the ISE is not resting on the bottom of the container, the white reference contacts near the tip of the electrode are immersed, and no air bubbles are trapped below the ISE.
7. Enter the concentration value for the Low Standard (e.g., **1** for 1 mg/L).
8. After the voltage reading stabilizes, click Keep.
9. To save the calibration to the sensor, follow the steps below:
   a. Click the Calibration Storage tab at the top of the dialog box.
   b. Click Set Sensor Calibration. Click Set.
   c. Click Done to continue. Click Write to complete the process.

Calibrating the Ammonium ISE with LabQuest App

1. Connect the Ammonium ISE to LabQuest. Choose Calibrate from the Sensors menu and select Calibrate Now.
2. **High Standard Calibration Point:** The Ammonium ISE should still be soaking in the High Standard. The ISE should not rest on the bottom of the container, and the small white reference contacts near the tip of the electrode should be immersed. Make sure no air bubbles are trapped below the ISE.
3. Enter the concentration of the High Standard (e.g., **100** for 100 mg/L) for Reading 1.
4. After the voltage reading stabilizes (~2 minutes), tap Keep.
5. **Low Standard Calibration Point:** Remove the ISE from the High Standard, rinse well with distilled water, and gently blot the ISE dry with a paper towel. Place the ISE into the Low Standard. Make sure the ISE is not resting on the bottom of the container, the white reference contacts near the tip of the electrode are immersed, and no air bubbles are trapped below the ISE.
6. Enter the concentration of the Low Standard (e.g., **1** for 1 mg/L) for Reading 2.
7. After the voltage reading stabilizes, tap Keep.
8. To save the calibration to the sensor, follow the steps below:
   a. Tap Storage.
   b. Tap Save Calibration to Sensor. Tap OK.
   c. Tap OK to complete the process.

Calibrating the Ammonium ISE with TI Graphing Calculators

Enter the calibration routine for your data-collection program. Consult the reference material for the calculator's program or app for the specific information concerning the calibration steps.

- **High Standard Calibration Point:** The Ammonium ISE should still be soaking in the High Standard. The ISE should not rest on the bottom of the container, and the small white reference contacts near the tip of the electrode should be immersed. Make sure no air bubbles are trapped below the ISE. Enter the concentration of the High Standard (e.g., **100** for 100 mg/L).

- **Low Standard Calibration Point:** Remove the ISE from the High Standard, rinse well with distilled water, and gently blot the ISE dry with a paper towel. Place the ISE into the Low Standard. Make sure the ISE is not resting on the bottom of the container, the white reference contacts near the tip of the electrode are immersed, and no air bubbles are trapped below the ISE. Enter the concentration of the Low Standard (e.g., **1** for 1 mg/L).

Collecting Data

1. Make sure the sensor is properly calibrated. If the meter has a reading of 1.0 mg/L and the sensor is not in a 1.0 mg/L solution, you need to calibrate. After calibration, rinse off the tip of the ISE and blot it dry with a paper towel.
2. Insert the tip of the ISE into the aqueous sample to be tested. **Important**: Make sure the ISE is not resting on the bottom of the container, the white reference contacts near the tip of the electrode are immersed, and no air bubbles are trapped below the ISE. **Note**: Do not completely submerge the sensor. The handle is not waterproof.
3. Hold the ISE still until the reading stabilizes and record the displayed reading. **Note**: With some aqueous samples, especially those at high concentrations, it could take several minutes for the reading of the Ammonium ISE to stabilize. If you know the approximate concentrations of your samples, it is best to analyze them from lowest concentration to highest.

Using the Ammonium ISE with Other Vernier Sensors

Some combinations of sensors interfere with each other when placed in the same solution. The degree of interference depends on many factors. For more information, see www.vernier.com/til/638/

Storing the Ion-Selective Electrode

Proper care and storage are important for optimal longevity of your Ammonium ISE.

- Long-term storage of the ISE (longer than 24 hours): Moisten the sponge in the bottom of the long-term storage bottle with distilled water. When you finish using the ISE, rinse it off with distilled water and blot it dry with a paper towel. Loosen the lid of the long-term storage bottle and insert the ISE. **Note**: The tip of the ISE should NOT touch the sponge. Also, make sure the white reference mark is inside the bottle. Tighten the lid. This will keep the electrode in a humid environment, which prevents the reference junctions from completely drying out.
- Short-term wet storage (less than 24 hours): Fill the Short-Term ISE Soaking bottle 3/4 full with High Standard. Loosen the cap, insert the electrode into the bottle, and tighten.

How the Ion-Selective Electrode Works

The Vernier Ammonium Ion-Selective Electrode (ISE) is a membrane-based electrode that measures a specific ion (NH_4^+) in an aqueous solution. When the membrane of the electrode is in contact with a solution containing the specific ion, a voltage, dependent on the level of that ion in solution, develops at the membrane. The ISE is a combination style electrode. The voltage develops in relation to an internal Ag/AgCl reference electrode. The ISE measures for the specific ion concentration directly. Samples need to be aqueous to avoid contaminating or dissolving the membrane. The Vernier Ammonium Ion-Selective Electrode has a solid polymer membrane. The membrane is a porous plastic disk, permeable to the ion exchanger, but impermeable to water. It allows the sensing cell to contact the sample solution and separates the internal filling solution from the sample.

The voltage developed between the sensing and reference electrodes is a measure of the concentration of the reactive ion being measured. As the concentration of the ion reacting at the sensing electrode varies, so does the voltage measured between the two electrodes.

As described in the Nernst Equation, ISE response is a linear equation:

$$E = E_o + m(\ln a)$$

where E is the measured voltage, E_o is the standard potential for the combination of the two half cells, m is the slope, ln is the natural logarithm, and a is the activity of the measured ion species.

Assuming the ionic strength is fairly constant, the Nernst equation may be rewritten to describe the electrode response to the concentration, C, of the measured ion species:

$$E = E_o + m(\ln C)$$

Specifications

Range	1 to 18,000 mg/L (or ppm)
Reproducibility (precision)	±10% of full scale (calibrated 1 to 100 mg/L)
Interfering ions	K^+
pH range	4–7.5 (no pH compensation)
Temperature range	0–40°C (no temperature compensation)
Electrode slope	+56 ±4 mV/decade at 25°C
Calibration voltages, typical	High (100 mg/L) 2.1 V, Low 1.3 V (1 mg/L)
Electrode resistance	1 to 4 MΩ
Minimum sample size	must be submerged 1.1 in

Maintaining and Replacing the ISE Standard Calibration Solutions

Having accurate standard solutions is essential for performing good calibrations. The two standard solutions that were included with your ISE can last a long time if you take care not to contaminate them. At some point, you will need to replenish your supply of standard solutions. Vernier sells replacement standards in 500 mL volumes. Order codes are:

NH4-LST: Ammonium Low Standard, 1 mg/L
NH4-HST: Ammonium High Standard, 100 mg/L

To prepare your own standard solutions, use the information in the table below. **Note**: Use glassware designed for accurate volume measurements, such as volumetric flasks or graduated cylinders. All glassware must be very clean.

Standard Solution	Concentration (mg/L or ppm)	Preparation Method Using High Quality Distilled Water
Ammonium High Standard	100 mg/L NH_4^+ as N	0.382 g NH_4Cl / 1 L solution
Ammonium Low Standard	1 mg/L NH_4^+ as N	Dilute the High Standard by a factor of 100

Replacement Modules

The Ammonium ISE has a PVC membrane module with a limited life expectancy. The module is warranted to be free from defects for a period of 1 year from the date of purchase. It is possible, however, that a membrane module will work well after the warranty period. If you notice a reduced response (e.g., distinctly different voltages or voltage ranges during calibration), then it is probably time to replace the membrane module. **Important**: Do not order membrane modules far in advance; the process of degradation takes place even when the modules are stored on the shelf.

Using Ionic Strength Adjustor (ISA) Solutions to Improve Accuracy

For optimal results at low concentrations of ions, a standard method for making measurements with ion-selective electrodes is to add ionic strength adjustor (ISA) solutions to each of your standard solutions and samples.

Adding an ISA ensures that the total ion activity in each solution being measured is nearly equal, regardless of the specific ion concentration. This is especially important when measuring very low concentrations of specific ions. The ISA contains no ions common to the ISE itself. **Note**: The addition of ISA to samples or standards does not need to be highly accurate. You can add the ISA solution dropwise to a sample using a disposable plastic Beral pipet. We recommend using 0.25 M magnesium acetate solution prepared in 0.5 M acetic acid solution as the ISA for the Ammonium ISE. To prepare this solution, dissolve 53.6 grams of magnesium acetate in sufficient 0.5 M acetic acid solution to make 1.0 liter. Commonly, ISA is added in a 1:50 ratio, or 1 mL of ISA added to 50 mL of water to be tested.

Using the Ammonium ISE

The Ammonium Ion-Selective Electrode (ISE) can be used to determine concentrations of NH_4^+ ions in aqueous solutions, in units of mg/L, ppm, or mol/L. Concentrations of aqueous ammonium ions should not be mistaken for concentration of aqueous ammonia, or NH_3(aq). The concentrations of these two species, though different, are often involved in the same equilibrium reaction:

$$\text{Reaction 1: } NH_3(aq) + H^+(aq) \longleftrightarrow NH_4^+(aq)$$

In a more acidic environment, higher concentrations of H+ ions will cause this reaction to shift toward the right, resulting in higher concentrations of NH_4^+. In a more basic (alkaline) environment, the concentration of NH_4^+ will be lower, causing the reaction to shift toward the reactants, producing higher concentrations of NH_3. At pH values greater than 10 (see Figure 1), most of the ammonium ions will be converted to ammonia. At pH values less than 7.5, most of the aqueous ammonia will be converted to ammonium ions.

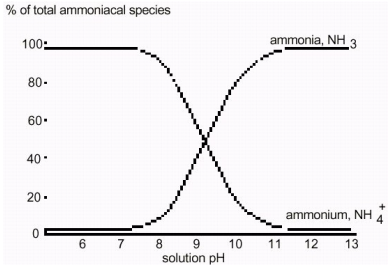


Figure 1

Sampling Freshwater Samples for Ammonium Concentration

While permissible levels of ammonium in drinking water should not exceed 0.5 mg/L, streams or ponds near heavily fertilized fields may have higher concentrations of this ion. Fertilizers containing ammonium sulfate, $(NH_4)_2SO_4$, or ammonium nitrate, NH_4NH_3, may result in runoff from fields containing higher levels of the ammonium ion, NH_4^+. Monitoring ammonium levels on a stream that borders fertilized fields may show significant seasonal differences in NH_4^+ concentrations. In this kind of study, you may also take pH measurements in your water samples; as indicated in the previous paragraph, higher or lower pH values can greatly affect the ratio of NH_4^+ / NH_3 in a sample. Since the Ammonium ISE measures only NH_4^+ levels, you may want to adjust your samples to the same pH value each time you make measurements; this may not be necessary if you have relatively "hard" water. Hard water is naturally buffered against changes in pH.

Expressing Ammonium Concentration

Concentrations of ammonium are often expressed in units of mg/L NH_4^+ as N. Here is a calculation for a 100 mg/L NH_4^+ as N standard solution that is prepared by adding solid NH4Cl to distilled water:

$$\frac{100\ \text{mg}\ NH_4^+}{1\ \text{L}} \times \frac{1\ \text{g}\ NH_4^+}{1000\ \text{mg}\ NH_4^+} \times \frac{53.5\ \text{g}\ NH_4Cl}{14.0\ \text{g}\ NH_4^+ - N} = 0.382\ \text{g}\ NH_4Cl/\text{Lsolution}$$

How Can I Have My ISE Read mV Output Instead of mg/L?

The amplification equation is: V = 0.00727*mV + 1.223

Therefore, the reverse amplification equation, solving for mV, would be:

mV = 137.55*V – 0.1682

Warranty

Vernier warrants this product to be free from defects in materials and workmanship for a period of five years from the date of shipment to the customer. This warranty does not cover damage to the product caused by abuse or improper use. ISE modules are covered by a one-year warranty.

Additional Vernier Ion-Selective Electrodes

Vernier sells Ion-Selective Electrodes that measure the concentration of calcium (Ca^{2+}), chloride (Cl^-), potassium (K^+) and nitrate (NO_3^-) ions in aqueous solutions. Order codes are:

- Calcium Ion-Selective Electrode: CA-BTA
- Chloride Ion-Selective Electrode: CL-BTA
- Nitrate Ion-Selective Electrode: NO3-BTA
- Potassium Ion-Selective Electrode: K-BTA

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