

# Ammonium Ion-Selective Electrode BNC

(Order Code NH4-BNC)



The Vernier Ammonium Ion-Selective Electrode BNC is used to measure the concentration of ammonium ( $\text{NH}_4^+$ ) ions in aqueous samples. It is designed to be used with the Vernier Electrode Amplifier (order code EA-BTA) or Vernier Go Wireless<sup>®</sup> Electrode Amplifier (order code GW-EA).

## Inventory of Items Included with the Ammonium ISE

- Ion-Selective Electrode with BNC terminated end, packed with a storage bottle
- 30 mL bottle of High Standard solution with SDS (100 mg/L  $\text{NH}_4^+\text{-N}$ )
- 30 mL bottle of Low Standard solution with SDS (1 mg/L  $\text{NH}_4^+\text{-N}$ )
- Short-Term ISE Soaking Bottle

**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.

Here is the general procedure to follow when using the Ammonium ISE to measure mV:

1. Connect the Ammonium ISE to a Vernier electrode amplifier.
2. Connect the electrode amplifier to the interface (if required).
2. Start the data-collection software.
3. The software will automatically load a default data-collection setup. Change the units to mV, if necessary. You are now ready to collect data.

**Important:** Do not fully submerge the sensor.

## Preparing the Ammonium ISE for Use

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.

## Collecting Data

1. Make sure the sensor is connected to a Vernier amplifier.
2. Connect the electrode amplifier to the interface (if required).
3. Start the data-collection software. The software will automatically load a default data-collection setup. Change the units to mV, if necessary.
4. Remove the electrode from the soaking solution (high standard). Thoroughly rinse the lower section of the probe, especially around the tip, using distilled or deionized water. Blot dry with a paper towel.
5. 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.
6. 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.

## How the Ion-Selective Electrode Works

Combination Ion-Selective Electrodes consist of an ion-specific (sensing) half-cell and a reference half-cell. The ion-specific half-cell produces a potential which is measured against the reference half-cell depending on the activity of the target ion in the measured sample. The ion activity and the potential reading change as the target ion concentration of the sample changes. The relationship between the potential measured with the ISE and the ion activity, and thereby the ion concentration in the sample, is described by the Nernst equation:

$$E = E_o - 2.303 \frac{RT}{nF} \log(C + C_o)$$

$E$  = measured potential (mV) between the ion-selective and the reference electrode

$E_o$  = standard potential (mV) between the ion-selective and reference electrodes

$R$  = Universal gas constant ( $R = 8.314 \text{ J mol}^{-1} \text{ K}^{-1}$ )

$T$  = Temperature in K (Kelvin), with  $T(\text{K}) = 273.15 + t^\circ\text{C}$  where  $t$  is the temperature of the measured solution in  $^\circ\text{C}$ .

$F$  = Faraday constant ( $96485 \text{ C mol}^{-1}$ )

$n$  = valence of the ion

$C$  = concentration of ion to be measured

$C_o$  = detection limit

Since  $R$  and  $F$  are constant, they will not change. The electrical charge of the ion (valence) to be measured is also known. Therefore, this equation can be simplified as:

$$E = E_o - S \bullet \log(C + C_o)$$

where  $S = -2.303 \frac{RT}{nF}$  is the ideal slope of the ISE.

The following table describes **ideal behavior**:

Ion Examples	n (valence of ion)	S (at 25 °C), mV/decade
Calcium (Ca <sup>2+</sup> )	+2	+29.58
Potassium (K <sup>+</sup> ), Ammonium (NH <sub>4</sub> <sup>+</sup> )	+1	+59.16
Nitrate (NO <sub>3</sub> <sup>-</sup> ), Chloride (Cl <sup>-</sup> )	-1	-59.16

Assuming  $C_0$  is near zero, the equation can be rewritten as:

$$C = 10^{[(E - E_0) / S]}$$

allowing for the calculation of the ion concentration.

It is very important to note that this table reflects ideal behavior. Ion-selective electrodes have slopes that are typically lower than ideal. It is generally accepted that an ISE slope from 88–101% of ideal is allowable. The slope ( $S$ ) is an indicator of ISE performance. If the slope changes significantly over time it may indicate that it is necessary to replace the ISE sensor tip.

### Convert Potential to Concentration (Optional)

To measure the mV readings from an aqueous sample, calibration is not required. To convert mV readings to concentration (mg/L or ppm), you will use a modified version of the Nernst Equation:

$$C = 10^{[(E - E_0) / S_m]}$$

$C$  = concentration of ion to be measured (mg/L or ppm)

$E$  = measured potential of sample (mV)

$E_0$  = measured potential (mV) at a  $C = 1$  mg/L NH<sub>4</sub><sup>+</sup> -N concentration

$S_m$  = measured electrode slope in mV/decade

The value of  $S_m$ , the measured electrode slope, is determined by measuring the potential of two standard solutions, and solving the equation below:

$$S_m = - [(Low\ Standard - High\ Standard) / \# \text{ of decades}^*]$$

\*A decade is defined as the factor of the difference between the two standard solutions. For example, the difference between a 1 mg/L standard and a 100 mg/L standard is 2 decades (a factor of 100 difference, or  $1 \times 10^2$ ).

### Example Calculation, converting mV to mg/L

For this example, the measured quantities are shown in the chart below:

Solution	Measured Potential
1 mg/L NH <sub>4</sub> <sup>+</sup> standard	0 mV
100 mg/L NH <sub>4</sub> <sup>+</sup> standard	116 mV
unknown sample	88 mV

$$S_m = - \frac{(0 \text{ mV} - 116 \text{ mV})}{2 \text{ decades}} = +58 \text{ mV/decade}$$

$$C = 10^{[(88 \text{ mV} - 0 \text{ mV}) / 58 \text{ mV/decade}]} = 33 \text{ mg/L NH}_4^+ \text{-N}$$

### Units of Ammonium Concentration

Concentrations of ammonium are often expressed in units of mg/L NH<sub>4</sub><sup>+</sup> as N, or NH<sub>4</sub><sup>+</sup>-N, also known as “ammonium-nitrogen”. This means that the concentration of ammonium is expressed with regard to the element nitrogen alone. The standards that are included with your Ammonium ISE have concentrations of 1 and 100 mg/L NH<sub>4</sub><sup>+</sup>-N. Here is the calculation for a 100 mg/L NH<sub>4</sub><sup>+</sup>-N standard solution that is prepared by adding solid NH<sub>4</sub>Cl to distilled water:

$$\frac{100 \text{ mg NH}_4^+}{1 \text{ L}} \times \frac{1 \text{ g NH}_4^+}{1000 \text{ mg NH}_4^+} \times \frac{53.5 \text{ g NH}_4\text{Cl}}{14.0 \text{ g NH}_4^+ \text{-N}} = 0.382 \text{ g NH}_4\text{Cl/L solution}$$

To convert concentration from NH<sub>4</sub><sup>+</sup>-N to NH<sub>4</sub><sup>+</sup> you will refer to the percent composition of nitrogen in an ammonium ion, as shown below using 100 mg/L NH<sub>4</sub><sup>+</sup>-N as an example:

$$\frac{100 \text{ mg NH}_4^+}{1 \text{ L}} \times \frac{53.5 \text{ g NH}_4^+}{14.0 \text{ g NH}_4^+ \text{-N}} = 382 \text{ mg/L NH}_4^+$$

### 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/](http://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.

## Specifications

Range (mV)	-450 mV to +1100 mV (EA-BTA) -1100 mV to +1100 mV (GW-EA)
Range (concentration)	1 to 18,000 mg/L (or ppm)
Reproducibility (precision)	±30 mV
Interfering ions	K <sup>+</sup> , Li <sup>+</sup> , Na <sup>+</sup> , Cs <sup>+</sup> , Mg <sup>3+</sup> , Ca <sup>2+</sup> , Sr <sup>2+</sup> , Ba <sup>2+</sup>
pH range	2–7 (no pH compensation)
Temperature range	0–40°C (no temperature compensation)
Electrode slope	+55 ±3 mV/decade at 25°C
Electrode resistance	0.1 to 5 MΩ
Minimum sample size	must be submerged 2.8 cm (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 <sub>4</sub> <sup>+</sup> as N	0.382 g NH <sub>4</sub> Cl / 1 L solution
Ammonium Low Standard	1 mg/L NH <sub>4</sub> <sup>+</sup> as N	Dilute the High Standard by a factor of 100

## Ammonium ISE Replacement Membrane 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.

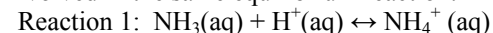
## Using Ionic Strength Adjustor (ISA) Solutions to Improve Accuracy

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 solutions 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.

## Ammonium in the Environment

The Ammonium Ion-Selective Electrode (ISE) can be used to determine concentrations of NH<sub>4</sub><sup>+</sup> 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<sub>3</sub>(aq). The concentrations of these two species, though different, are often involved in the same equilibrium reaction:



In a more acidic environment, higher concentrations of H<sup>+</sup> ions will cause this reaction to shift toward the right, resulting in higher concentrations of NH<sub>4</sub><sup>+</sup>. In a more basic (alkaline) environment, the concentration of NH<sub>4</sub><sup>+</sup> will be lower, causing the reaction to shift toward the reactants, producing higher concentrations of NH<sub>3</sub>. 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.

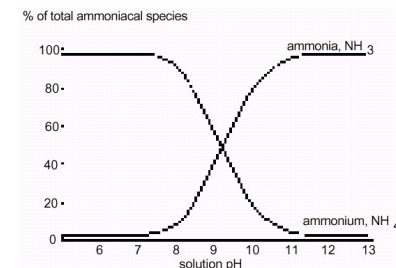


Figure 1

## 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<sub>4</sub>)<sub>2</sub>SO<sub>4</sub>, or ammonium nitrate, NH<sub>4</sub>NH<sub>3</sub>, may result in runoff from fields containing higher levels of the ammonium ion, NH<sub>4</sub><sup>+</sup>. Monitoring ammonium levels on a stream that borders fertilized fields may show significant seasonal differences in NH<sub>4</sub><sup>+</sup> 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<sub>4</sub><sup>+</sup> / NH<sub>3</sub> in a sample. Since the Ammonium ISE measures only NH<sub>4</sub><sup>+</sup> 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.

## 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.

## Related Products

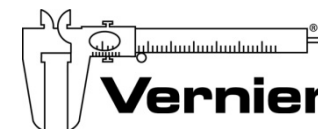
Vernier sells Ion-Selective Electrodes that measure the concentration of calcium ( $\text{Ca}^{2+}$ ), chloride ( $\text{Cl}^-$ ), potassium ( $\text{K}^+$ ) and nitrate ( $\text{NO}_3^-$ ) ions in aqueous solutions.

Order codes are:

- Calcium Ion-Selective Electrode: CA-BNC
- Chloride Ion-Selective Electrode: CL-BNC
- Nitrate Ion-Selective Electrode: NO3-BNC
- Potassium Ion-Selective Electrode: K-BNC
- Electrode Amplifier: EA-BTA
- Go Wireless Electrode Amplifier: GW-EA

## Replacement Products

- Standard High Ammonium ISE Solution: NH4-HST
- Standard Low Ammonium ISE Solution: NH4-LST
- Ammonium Replacement Module: NH4-MOD



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