Calcium ISE BNC Connector

(Order Code CA-BNC)

The Vernier Calcium Ion-Selective Electrode BNC Connector is used to measure the concentration of calcium (Ca^{2+}) ions in aqueous samples. It is designed to be used with the Vernier Electrode Amplifier (order code EA-BTA) or Vernier Go Wireless® Electrode Amplifier (order code GW-EA).

Inventory of Items Included with the Calcium ISE

- Ion-Selective Electrode with BNC terminated end, packed with a storage bottle
- 30 mL bottle of High Standard solution with SDS (1000 mg/L Ca^{2+})
- 30 mL bottle of Low Standard solution with SDS (10 mg/L Ca^{2+})
- Short-Term ISE Soaking Bottle

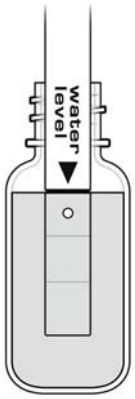
NOTE: Vernier products are designed for educational use. Our products are not designed nor are they recommended for any industrial, medical, or commercial process such as life support, patient diagnosis, control of a manufacturing process, or industrial testing of any kind.

Preparing the Calcium 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

Calibration is required for use. Detailed instructions based on your data-collection program can be viewed at these web addresses:

Logger *Pro* 3: www.vernier.com/til/2341/

LabQuest App: www.vernier.com/til/3394/

Graphical Analysis App: www.vernier.com/til/3395/

- **High Standard Calibration Point:** The Calcium ISE should still be soaking in the High Standard from Part I. 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., **1000** for 1000 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., **10** for 10 mg/L).

Collecting Data

1. Make sure the sensor is connected to a Vernier amplifier and 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 Calcium 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 Calcium 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 Calcium 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 Calcium Ion-Selective Electrode (ISE) is a membrane-based electrode that measures a specific ion (Ca^{2+}) 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 Calcium 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 40,000 mg/L (or ppm)
Reproducibility (precision)	±10% of full scale (calibrated 10 to 1000 mg/L)
Interfering ions	Pb^{2+}, Hg^{2+}, Sr^{2+}, Cu^{2+}, Ni^{2+}
pH range	3–10 (no pH compensation)
Temperature range	0–40°C (no temperature compensation)
Electrode slope	+56 ±4 mV/decade at 25°C
Calibration voltages, typical	High (1000 mg/L) 1.9 V, Low 1.5 V (10 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:

CA-LST: Calcium Low Standard, 10 mg/L
CA-HST: Calcium High Standard, 1000 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
Calcium (Ca^{2+}) ISE High Standard	1000 mg/L as Ca	2.771 g $CaCl_2$ / 1 L solution or 3.669 g $CaCl_2 \cdot 2H_20$ / 1 L solution
Calcium (Ca^{2+}) ISE Low Standard	10 mg/L as Ca	Dilute the High Standard by a factor of 100 (from 1000 mg/L to 10 mg/L).*

*Perform two serial dilutions as described below.

a. Combine 100 mL of the High Standard with 900 mL of distilled water. Mix well.
b. Combine 100 mL of the solution made in Step a with 900 mL of distilled water. Mix well.

Calcium ISE Replacement Membrane Modules

The Calcium Ion-Selective Electrode has a PVC membrane with a limited life expectancy. It is warranted to be free from defects for a period of twelve (12) months from the date of purchase; it is possible, however, that you may get somewhat longer use than the warranty period. If you start to notice a reduced response (e.g., distinctly different voltages or voltage ranges during calibration), it is probably time to replace the membrane module. **Important**: Do not order membrane modules far in advance of the time you will be using them; the process of degradation takes place even when they are stored on the shelf.

Using Ionic Strength Adjuster Solutions to Improve Accuracy

For optimal results at low concentrations of calcium ions, a standard method for taking measurements with the Calcium Ion-Selective Electrode (ISE) is to add ionic strength adjuster (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 calcium ions. The ISA contains no ions common to the Calcium ISE itself. **Note**: The additions of ISA to samples or standards described below do not need to have a high level of accuracy—combining the ISA solution and sample solution counting drops using a disposable Beral pipet works fine.

Add the 1.0 M KCl ISA solution (7.46 g KCl / 100 mL solution) to the Ca^{2+} standard or to the solution being measured, in a ratio of 1 part of ISA (by volume) to 50 parts of total solution (e.g., 1 mL of ISA to 50 mL of total solution, or 2 drops of ISA to 5 mL of total solution).

Using the Calcium ISE

Your Calcium Ion-Selective Electrode (ISE) can be used to determine the concentration of aqueous Ca^{2+} ions, in the range of 1.8 to 40,100 mg/L. It can be especially useful in determining "hardness of water." Calcium ions are often found in freshwater samples as a result of water flowing over soil and mineral deposits containing limestone, chalk, magnesite, or dolomite. In one common reaction, limestone is dissolved according to the reaction

$$CaCO_3(s) + H+(aq) \longleftrightarrow Ca^{2+}(aq) + HCO_3^-(aq)$$

This reaction and others similar to it produce water with a relatively high concentration of Ca^{2+} ions, and lesser concentrations of Mg^{2+} and Fe^{3+} ions—known as hard water.

Using the Calcium ISE to Determine Water Hardness as Ca^{2+}

Many methods of determining water hardness use "total hardness," or the sum of hardness due to Mg^{2+} and Ca^{2+}. Since the Ca^{2+} concentration of freshwater usually exceeds that of Mg^{2+}, determining the Ca^{2+} concentration alone is a good indicator of water hardness—we will refer to this measurement as "calcium hardness." For best results, calibrate the Calcium ISE using the 10 mg/L and 1000 mg/L standards.

Using the standard solutions described here, your results will be in units of mg/L of Ca^{2+}. Units of calcium hardness are usually expressed as "calcium hardness as $CaCO_3$". To convert from units of mg/L of Ca^{2+} (150 mg/L is used in this example) to units of calcium hardness as $CaCO_3$, in mg/L, you would use this expression:

$$\frac{150\ \text{mg}\ Ca^{2+}}{1\ \text{L}} \times \frac{100\ \text{g}\ CaCO_3}{40\ \text{g}\ Ca^{2+}} = 374\ \text{mg / L (hardness as}\ CaCO_3)$$

It is important to remember that total hardness, taking into account both the Ca and Mg levels, will be about 1.5 times higher than your calcium hardness value. Water hardness varies considerably in different parts of the United States, from levels of less than 60 mg/L (total hardness as $CaCO_3$) in Washington, Oregon, Louisiana, Mississippi, Tennessee, and New England, to levels exceeding 250 mg/L in Midwestern states (Ohio, Indiana, Illinois, Iowa, Nebraska, South Dakota, and Oklahoma). Water with a hardness as $CaCO_3$ level greater than 120 mg/L is considered to be "hard," while levels exceeding 180 mg/L are referred to as "very hard." Total water hardness, the sum of calcium and magnesium hardness in mg/L $CaCO_3$, can be determined by titration with EDTA. A protocol can be found in our lab book *Water Quality with Vernier*. A plot of ln [Ca^{2+}] (natural log of calcium ion concentration) *vs.* volume is used to determine the equivalence point. The second derivative can be used to calculate the point of maximum inflection at the equivalence point of the titration.

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 BNC Electrodes

Vernier sells Ion-Selective Electrodes that measure the concentration of ammonium (NH_4^+), chloride (Cl^-), potassium (K^+) and nitrate (NO_3^-) ions in aqueous solutions. Order codes are:

- Ammonium Ion-Selective Electrode: NH4-BNC
- Chloride Ion-Selective Electrode: CL-BNC
- Nitrate Ion-Selective Electrode: NO3-BNC
- Potassium Ion-Selective Electrode: K-BNC

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