Ion Selective Electrode Probe

- KDS-1064 Calcium
- KDS-1065 Ammonium
- KDS-1066 Nitrate
- KDS-1067 Chloride

Type: Ion selective electrode
Range: 1 M to 5x10^-7 M (40,000 ~ 0.01 ppm)

Sensor description
The Ion Selective Electrode is a hand crafted PVC membrane ion-selective electrode which measures nitrate ions in aqueous solutions simply, quickly, economically, and accurately. They are used to conduct water quality studies. The concentration range of the Nitrate Electrode is 1 M to 7 x 10^-7 M or 0.01 ppm to 40,000 ppm.

The ISE (Ion Selective Electrode) set consists of the FastFil Ion selective combination electrode, combining the Ion Selective electrode and the reference electrode, and ISE Probe amplifier.

This product is to be used for educational purpose only. It is not appropriate for industrial, medical, research, commercial use.
**Typical Experiments**

Ion Selective electrodes are used in a wide variety of applications for determining the concentrations of various ions in aqueous solutions. The following is a list of some of the main areas in which Ion Selective electrodes have been used:

- Conducting water quality studies
- Determining the concentration of ammonium ions in aqueous solutions
- Pollution Monitoring: CN, F, S, Cl, NO$_3$, etc., in effluents, and natural waters
- Agriculture: NO$_3$, Cl, NH$_4$, K, Ca, I, and CN in soils, plant material, fertilizers and feedstuffs
- Food Processing: NO$_3$, NO$_2$ in meat preservatives
- Salt content of meat, fish, dairy products, fruit juices, brewing solutions
- F in drinking water and other drinks
- Ca in dairy products and beer
- K in fruit juices and wine making effect of NO$_3$ in canned foods
- Detergent Manufacture: Ca, Ba, F for studying effects on water quality
- Paper Manufacture: S and Cl in pulping and recovery-cycle liquors
- Explosives: F, Cl, NO$_3$ in explosive materials and combustion products
- Electroplating: F and Cl in etching baths; S in anodizing baths
- Biomedical Laboratories: Ca, K, Cl in body fluids (blood, plasma, serum, sweat)
- F in skeletal and dental studies
- Education and Research: Wide range of applications
Figure 1: NO\textsubscript{3} Ion Selective Electrode

**How it works**

The Ion Selective Electrode (ISE) uses ion selective membrane to allow ions to penetrate to the electrode. A potential drop is developed between the two sides of the sensing membrane. This potential is proportional to the logarithm of the concentration of the Nitrate ion according with the Nernst equation:

$$ E = E_0 + S \cdot \ln(a) $$
Where $E$ is the measured voltage, $E_0$ the reference potential, $S$ – the slope and $a$ is the Nitrate activity.
The slope is given by:

$$S = \frac{RT}{nF}$$

Where $R$ is the gas constant, $T$ the temperature in Kelvin, $n$ – charge of the ion and $F$ is Faraday constant.

If the ionic strength is high and constant, Nernst equation can be written as:

$$E = E_0 + S \cdot \ln(C)$$

Where $C$ is the Ionic concentration.
To adjust the background ionic strength to a high and constant value, ionic strength adjuster (ISA) must be added to all samples and standards.
The potential develops due to the formation of a double layer consisting of a charged layer on the surface of the membrane of the ions sensed by the electrode and an opposite charged layer of counter ions from the sample (ions of opposite charge to the ones sensed by the electrode).

As with any measurement of potentials, all values are relative to the built in reference electrode whose potential is constant. The reference solution aids in making electrical contact between the reference electrode (which is not in physical contact with the sample) and the sample. It consists of a solution of a salt that is able to conduct electricity but does not interfere with the measurement of the ion of interest.

**Items included**

**Calcium ISE Probe**
- Combination Ca++ Electrode
- Calcium ISE Probe amplifier
- 1 oz Ca++ Reference Filling Solution (RF0005)
- 1 oz Ca++ Ionic Strength Adjuster (ISA) (AJ0004)
- 1 oz Ca++ 10ppm as Ca Standard (SD2054)
- 1 oz Ca++ 1000ppm as Ca Standard (SD2008)
Ammonium ISE Probe
- Combination NH₄⁺ Electrode
- Ammonium ISE Probe amplifier
- 1 oz. NH₄⁺ Reference Filling Solution (RF0012)
- 1 oz. NH₄⁺ Ionic Strength Adjuster (ISA) (AJ0015)
- 1 oz. NH₄⁺ 10ppm as N Standard (SD2052)
- 1 oz. NH₄⁺ 1000ppm as N Standard (SD2002)

Nitrate ISE Probe
- Combination NO₃⁻ Electrode(AC017)
- Nitrate ISE Probe amplifier(KDS-1066)
- 1 oz NO₃⁻ Reference Filling Solution (RF0011)
- 1 oz NO₃⁻ Ionic Strength Adjuster (ISA) (AJ0011)
- 1 oz NO₃⁻ 10ppm as N Standard (SD2051)
- 1 oz NO₃⁻ 1000ppm as N Standard (SD2030)

Chloride ISE Probe
- Combination Cl⁻ Electrode
- Chloride ISE Probe amplifier(KDS-1067)
- 1 oz Cl⁻ Reference Filling Solution (RF0007)
- 1 oz Cl⁻ Ionic Strength Adjuster (ISA) (AJ0013)
- 1 oz Cl⁻ 10ppm as Ca Standard (SD2053)
- 1 oz Cl⁻ 1000ppm as Ca Standard (SD2012)

Required Equipment
- ScienceCube Lite II, Pro or Max Series
- Wash bottle with distilled or de-ionized water
- Several clean beakers
- 1 mL, 10 mL and 100 mL pipettes

Electrode Preparation
1. The sensing element comes pre-mounted on the end of the electrode with a protective bottle, but can be removed by unscrewing the electrode end.
Caution: Do not touch the PVC membrane with your fingers or over tighten the sensing element

2. The reference chamber must be filled with Reference Fill Solution and remain open during testing and measuring:
   a) Slide the sleeve of the electrode cap down to uncover the fill hole (see Figure 2)
   b) Fill the reference chamber with the Reference Fill Solution provided above the reference fill line on the electrode (see Figure 1)

3. Shake the electrode downward like a thermometer to remove any air bubbles trapped inside.
4. Rinse the electrode with DI water, blot dry. **Do not rub dry.**
5. Condition the electrode in a 10ppm solution for 30 minutes.
6. After the conditioning period, rinse the tip of the electrode with DI water.

**Defining the sensor with ScienceCube Interface**
1. Turn on the Interface
2. Connect the Interface to the computer
3. Open ScienceCube program
4. Click Excel on the [Experiment] - [Setting], then click [Zero] to open a dialog: MultiLab will update the defined sensor in your data logger.

5. **High Standard Calibration Point:** The ISE should still be soaking in the High Standard. When the displayed value reading for Reading 1 stabilizes (~1 minute), click.

6. **Low Standard Calibration Point:** Remove the ISE from the High Standard, rinse well with distilled water from a wash bottle, and gently blot dry with a paper towel or lab wipe. Place the electrode into the Low Standard (included with your ISE).

   **Make sure the ISE is not resting on the bottom of the container, and that the small white reference contacts are immersed. Make sure no air bubbles are trapped below the ISE.**

### Checking Electrode Operation (Slope)

Check the electrode every day when measurements will be conducted

1. Connect the electrode to the Electrode Amplifier (KDS-1043), then connect the Probe to the Interface.

2. Place 100 mL DI water into a 150 mL beaker. Add 2 mL ISA to the DI water and stir thoroughly

3. Begin recording

4. Rinse the electrode with DI water, blot dry and place in the solution prepared in step 2

5. Pipette 1 mL of 1000 ppm Nitrate Standard into the beaker. Stir thoroughly and then record the potential (E1) in mVs when a stable reading is displayed.

6. Pipette 10 mL of the same standard into the same beaker. Stir thoroughly. When a stable reading is displayed, record the potential (E2) in mVs.

7. The difference between the second and the first potential readings (E1-E2) is defined as the electrode slope.

8. The normal range for the slope is:
   - Calcium : 27 mV at 25°C
   - Ammonium : 56 mV at 25°C
   - Nitrate : -56 mV at 25°C
   - Chloride : -56 mV at 25°C

### Troubleshooting

If the electrode slope is not within the normal range, the following procedure may restore the electrode.

1. Soak the electrode in the 10 ppm standard solution for 2 hours before use
2. Repeat "Checking Electrode Operation" procedure again

**Note:** All standard solutions should be prepared fresh. Use ISA in all solutions.

Periodically check the Reference Fill Solution level in the reference chamber.
The solution level must be above than the reference fill line (see Figure 1).
If the electrode slope is still outside the normal range after this procedure, replace the sensing module.

![Figure 4: replacing the Sensing Module](image)

**Reading a Sample with the Electrode**
Various procedures may be used to determine the concentration of a sample. The most common is the Direct Calibration method, which is described below.

In Direct Calibration a series of standard solutions of differing concentrations are used to calibrate the electrode. Then each sample requires only a single reading, which is compared with the calibration readings to obtain the sample concentration.
ISA is added to all solutions to ensure the samples and the standards have the same ionic strength.
Calibrate once a day before measurements.
The filling hole must remain open during measurements (see Figure 2).

**Set up:**
1. Prepare the electrode as described in "Electrode Preparation"
2. Connect the electrode to the ISE amplifier, then connect the amplifier to the data logger
3. Prepare two standard solutions that differ in concentration by a factor of ten. The standards should be at the same temperature as the sample
Measurement:
1. Place 100 mL of the more dilute standard into a 150 mL beaker. Add 2 mL of ISA. Stir thoroughly
2. Rinse electrode with DI water, blot dry and place in the beaker. Wait for a stable reading, and then record the voltage reading
3. Measure 100 mL of the more concentrated standard into a second 150 mL beaker. Add 2 mL of ISA and stir
4. Rinse electrode with DI water, blot dry and place in the second beaker. Wait for a stable reading, and then record the voltage reading of the second standard
5. On a semi-logarithmic graph paper, plot the voltage readings (linear axis) against the concentration (logarithmic axis). See Figure 5 for a typical calibration curve
Electrode Storage

Short Term:
Rinse the electrode thoroughly with DI water and place the tip in a diluted standard solution (10ppm is satisfactory) between measurements. Slide the sleeve up to close refill hole. Make sure that the reference electrolyte does not exhaust the solution that the electrode is stored in does not dry. We recommend cleaning with DI water (see long term storage) at least once a week for solid results.

Long Term:
Empty reference chamber of Reference Fill Solution. Flush reference chamber with DI water several times. Empty DI water from the reference chamber and store the electrode dry. Replace the storage bottle and hand tighten the storage bottle cap.
Follow procedures in "Electrode Preparation" and "Checking Electrode Operation" when using the electrode again.

Specifications:

Calcium ISE Probe
- Range: 1 M to 5 x 10^-7 M (40,000 – 0.02 ppm)
- 12-bit Resolution: 0.5mV
- **pH Range:** 2.5 to 11 pH
- **Temperature Range:** 0 to 40°C
- **Electrode Resistance:** 1 to 4MΩ
- **Reproducibility:** ±4%
- **Minimum Sample Size:** 3 mL in a 50 mL beaker
- **Interfering Ions:** Pb\(^{2+}\), Hg\(^{2+}\), Si\(^{2+}\), Fe\(^{2+}\), Cu\(^{2+}\), Ni\(^{2+}\), NH\(_3\)\(^{+}\), Li\(^+\), Tris\(^{+}\), K\(^+\), Ba\(^+\), Zn\(^{2+}\), Mg\(^{2+}\)

**Ammonium ISE Probe**
- **Range:** 1 M to 5 x 10\(^{-6}\) M (18,000 – 0.1 ppm)
- **12-bit Resolution:** 0.5mV
- **pH Range:** 4 to 10 pH
- **Temperature Range:** 0 to 50°C
- **Electrode Resistance:** 1 to 4MΩ
- **Reproducibility:** ±4%
- **Minimum Sample Size:** 3 mL in a 50 mL beaker
- **Interfering Ions:** K\(^+\), Na\(^+\)

**Nitrate ISE Probe**
- **Range:** 1 M to 5 x 10\(^{-7}\) M (14,000 – 0.1 ppm)
- **12-bit Resolution:** 0.5mV
- **pH Range:** 2.5 to 11 pH
- **Temperature Range:** 0 to 40°C
- **Electrode Resistance:** 1 to 4MΩ
- **Reproducibility:** ±4%
- **Minimum Sample Size:** 3 mL in a 50 mL beaker
- **Interfering Ions:** Pb\(^{2+}\), Hg\(^{2+}\), Si\(^{2+}\), Fe\(^{2+}\), Cu\(^{2+}\), Ni\(^{2+}\), NH\(_3\)\(^{+}\), Li\(^+\), Tris\(^{+}\), K\(^+\), Ba\(^+\), Zn\(^{2+}\), Mg\(^{2+}\)

**Chloride ISE Probe**
- **Range:** 1 M to 5 x 10\(^{-6}\) M (35,000 – 1.8 ppm)
- **12-bit Resolution:** 0.5mV
- **pH Range:** 2.0 to 12 pH
- **Temperature Range:** 0 to 80°C
- **Electrode Resistance:** less than 1 megohms
- **Reproducibility:** ±2%
- **Minimum Sample Size:** 3 mL in a 50 mL beaker
Interfering Ions: CN-, Br-, I-, OH-, S₂.

Solutions

Calcium ISE Probe

- 1000ppm Ca (0.249 M Ca): Dissolve 3.668g CaCl₂·2H₂O in DI water and dilute to 1000mL
- ISA 4M KCl: 300g KCl in 1000mL DI water
- Reference (1M KNO₃): 100g KNO₃ in 1000mL DI water

Ammonium ISE Probe

- 1000ppm NH₄⁺ (0.0554 M NH₄⁺): Dissolve 2.965g NH₄Cl in DI water and dilute to 1000mL
- ISA 1M NaCl: 58.443g NaCl in 1000mL DI water
- Reference (0.1M NaCl): 29.22g NaCl in 1000mL DI water

Nitrate ISE Probe

- 1000 ppm : 3 NO₃⁻ (0.0161 M NO₃⁻): Dissolve 1.631 g KNO₃ in DI water and dilute to 1000 mL
- ISA 2 M (NH₄)₂SO₄: 264.3 g (NH₄)₂SO₄ in 1000 mL DI water
- Reference 1 M (NH₄)₂SO₄: 132.1 g (NH₄)₂SO₄ in 1000 mL DI water

Chloride ISE Probe

- 1000ppm Cl (0.0282 M Cl): Dissolve 1.648g NaCl in DI water and dilute to 1000mL
- ISA 5M NaNO₃: 425g NaNO₃ in 1000mL DI water
- Reference (1M KNO₃): 100g KNO₃ in 1000mL DI water
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