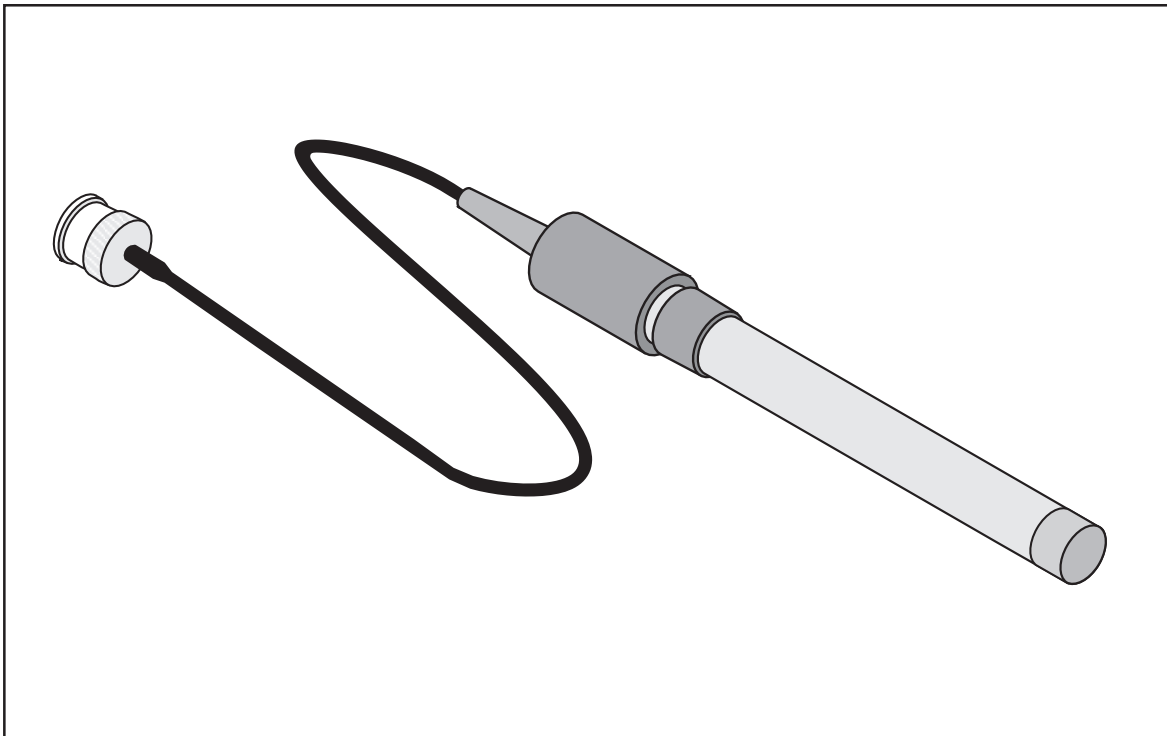*Instruction Manual and*
Experiment Guide for the
PASCO scientific
Model CI-6735

NITRATE ION SELECTIVE ELECTRODE

$7.50

better
ways to
teach science

Always use eye protection and gloves when working with chemicals.

Table of Contents

Copyright, Warranty, and Equipment Return

Copyright Notice

Limited Warranty

Credits

Equipment Return

Should the product have to be returned to PASCO scientific for any reason, notify PASCO scientific by letter, phone, or fax BEFORE returning the product. Upon notification, the return authorization and shipping instructions will be promptly issued.

➤ **NOTE:** NO EQUIPMENT WILL BE ACCEPTED FOR RETURN WITHOUT AN AUTHORIZATION FROM PASCO.

When returning equipment for repair, the units must be packed properly. Carriers will not accept responsibility for damage caused by improper packing. To be certain the unit will not be damaged in shipment, observe the following rules:

① The packing carton must be strong enough for the item shipped.

② Make certain there are at least two inches of packing material between any point on the apparatus and the inside walls of the carton.

③ Make certain that the packing material cannot shift in the box or become compressed, allowing the instrument come in contact with the packing carton.

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web: www.pasco.com

Introduction

The PASCO scientific Nitrate Ion Selective Electrode is used to quickly, simply, accurately, and economically measure nitrate in aqueous solutions.

Theory

The Nitrate Ion Selective Electrode consists of an electrode body containing a liquid internal filling solution in contact with a gelled organophilic membrane containing a nitrate ion exchanger. When the membrane is in contact with a solution containing free nitrate ions, an electrode potential develops across the membrane. This electrode potential is measured against a constant reference potential, using an ISE Amplifier and *Science Workshop* Interface. The level of nitrate ions, corresponding to the measured potential, is described by the Nernst equation:

$$E = E_0 - S \log X$$

where:

$$E = \text{measured electrode potential}$$
$$E_0 = \text{reference potential (a constant)}$$
$$S = \text{electrode slope } (\approx 55 \; \frac{\text{mV}}{\text{decade}})$$
$$X = \text{level of nitrate ions in solution}$$

The activity, X, represents the effective concentration of the ions in solution. The total nitrate ion concentration, C_t is the sum of free nitrate ion, C_f, and complexed or bound perchlorate ion, C_b. The electrode is able to respond to only the free ions, whose concentration is

$$C_f = C_t = C_b$$

Since nitrate ions form very few stable complexes, the free ion concentration may be equated to the total ion concentration.

The activity is related to the free ion concentration, C_f, by the activity coefficient, γ, by:

$$X = \gamma \, C_f$$

Activity coefficients vary, depending on total ions strength, I, defined as:

$$I = \tfrac{1}{2} \, \Sigma C_X Z_{X^2}$$

where:

$$C_X = \text{concentration of ion } X$$
$$Z_X = \text{charge of ion } X$$
$$\Sigma = \text{sum of all of the types of ions in the solution}$$

In the case of high and constant ionic strength relative to the sensed ion concentration, the activity coefficient, γ, is constant and the activity, X, is directly proportional to the concentration.

To adjust the background ionic strength to a high end constant value, ionic strength adjuster (ISA) is added to samples and standards. The recommended ISA for nitrate is $(NH_4)_2SO_4$. Solutions other than this may be used as ionic strength adjusters as long as ions that they contain do not interfere with the electrode's response to nitrate ions.

Strongly acidic (pH = 0 - 2) and strongly basic (pH = 12 - 14) solutions are particularly troublesome to measure. The high mobility of hydrogen and hydroxide ions in samples make it impossible to mask their effect on the junction potential with any concentration of equitransferent salt. One must either calibrate the electrode in the same pH range as the sample or use a known incremental method for ion measurement.

Equipment

- Nitrate Ion Selective Electrode
- Nitrate Ion Selective Electrode fill solution
- Pipette for fill solution
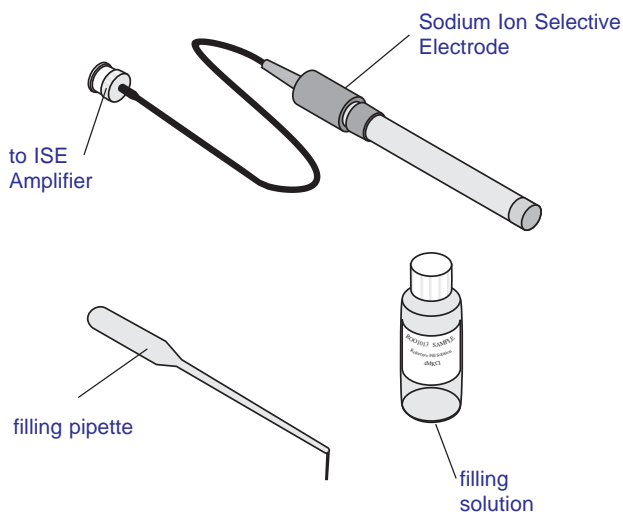
Figure 1.
Included Equipment

Additional Required:

Required Equipment

PASCO CI-6738 ISE (Ion Selective Electrode) Amplifier

- *ScienceWorkshop* 2.2.5 or higher
- PASCO *ScienceWorkshop* Computer Interface
- Semi-logarithmic 4-cycle graph paper for preparing calibration curves.
- Magnetic stir plate
- Lab-ware made of plastic, not glass, for all low level measurements

Required Solutions

The stock solutions listed in this section may be created as described in the text or ordered directly from PASCO. The solutions available for order, and their respective prices are listed on the 'ISE Working Solution Price List'.

- *Deionized or distilled water for solution and standard preparation*
- *Ionic Strength Adjuster (ISA) , 2 M $(NH_4)_2SO_4$*

  To prepare this solution, half fill a 1,000 ml volumetric flask with distilled water and add 264 grams of reagent-grade ammonium sulfate, $(NH_4)_2SO_4$. Swirl the flask gently to dissolve the solid. Fill the flask to the mark with distilled water, cap, and upend several times to mix the contents. ISA is added at the rate of 2 ml of ISA to each 100 ml of standard or sample to adjust the ionic strength to about 0.12 M.

- *Reference Filling Solution, 0.l M $(NH_4)_2SO_4$/0.0l M KCl*

- *Nitrate Standard, 0.1 M $NaNO_3$*

  To prepare this solution, add 8.50 grams of reagent-grade sodium nitrate to a one liter volumetric flask about half full of distilled water. Swirl the flask gently to dissolve the solid. Fill to the mark with distilled water, cap, and upend several times to mix the solution.

- *Nitrate Standard, 1,000 ppm NO_3^{-1}*

  To prepare this solution, add 1.37 grams of reagent-grade sodium nitrate to a one liter volumetric flask about half full with distilled water. Swirl the flask gently to dissolve the solid. Fill to the mark with distilled water, cap, and upend several times to mix the solution.

- *Nitrate Standard, 100 ppm NO_3^{-1}*

  To prepare this solution, add 0.61 grams of reagent-grade sodium nitrate to a one liter volumetric flask about half full with distilled water. Swirl the flask gently to dissolve the solid. Fill to the mark with distilled water, cap, and upend several times to mix the solution.
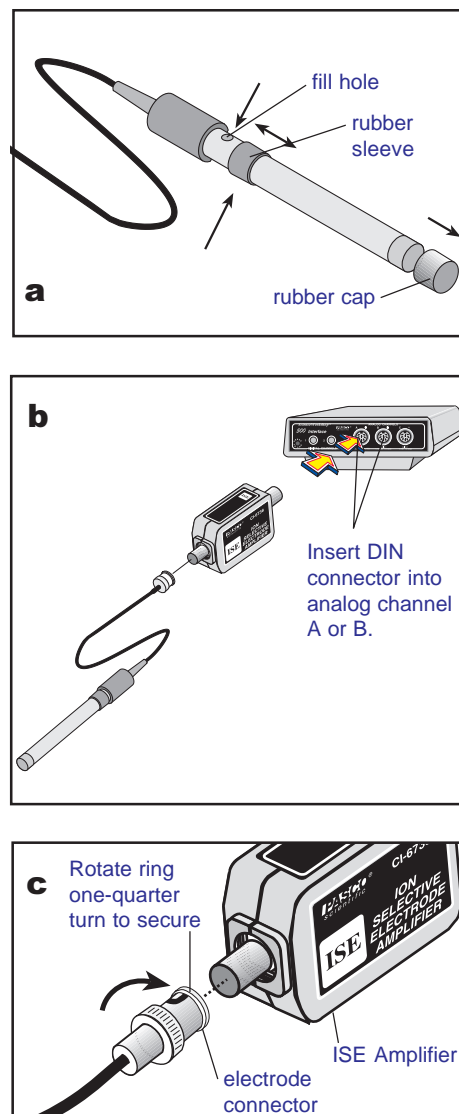
General Preparation

Electrode Preparation

1. Remove the rubber cap covering the electrode tip. Slide the rubber sleeve down away from the filling hole of the Nitrate Ion Selective Electrode. Fill the electrode with the included filling solution to a level just below the fill hole. Slide the rubber sleeve back over the filling hole (Figure 2a). Gently shake the electrode downward in the same manner as a clinical thermometer to remove any air bubbles that may be trapped behind the nitrate membrane. Prior to first usage, or after long term storage, immerse the nitrate membrane in nitrate standard for thirty minutes. The electrode is now ready for use.

2. Connect the Nitrate Ion Selective Electrode to the ISE Amplifier and insert the DIN connector of the ISE Amplifier into analog port A or B on a PASCO Computer Interface (Figures 2b and 2c).

Electrode Slope Check Using *Science Workshop* (check electrodes each day)

1. To a 150 ml glass beaker, add 100 ml of distilled water and 2 ml of ISA. Place the beaker on a magnetic stirrer and begin stirring at a constant rate. Start the *ScienceWorkshop* software, select the Ion Selective Electrode sensor, open a Digital display, change the number of digits to the right of the decimal from 1 to 3, and begin monitoring data. Lower the electrode tip into the solution.

2. Using a pipette, add 1 ml of 0.1 M or 1,000 ppm nitrate standard to the beaker. When the reading has stabilized, record the voltage reading indicated in the Digits display.

Figure 2
Equipment Setup. **a**: filling the electrode with filling solution; **b & c**: connecting the electrode to the ISE Amplifier and to the computer interface

3. Using a pipette, add 10 ml of the same nitrate standard used above to the beaker. When the reading has stabilized, record the voltage reading indicated in the Digits display.

4. Determine the difference between the two readings. A difference of 55 ±2 mV indicates correct electrode operation assuming the solution temperature is between 20 °C and 25 °C. See the ***Troubleshooting*** sections if the potential change is not within this range.

> ➤ *Note: Slope is defined as the change in potential observed when the concentration changes by a factor of 10.*

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Measurement

Measuring Hints

- All samples and standards should be at the same temperature for precise measurement. A difference of 1 °C in temperature will result in a 2% measurement error.

- The sensing membrane is normally subject to water uptake and might appear milky. This has no effect on performance.

- Constant, but not violent, stirring is necessary for accurate measurement. Magnetic stirrers can generate sufficient heat to change the solution temperature. To counteract this effect, place a piece of insulating material, such as Styrofoam sheet, between the stirrer and beaker.

- Always rinse the electrode with distilled water and blot dry between measurements. Use a clean, dry tissue to prevent cross-contamination.

- For samples with high ionic strength, prepare standards whose composition is similar to the sample.

- Always check to see that the membrane is free from air bubbles after immersion into standard or sample.

- A slow responding electrode may be caused by interferences to the electrode. To restore proper performance, soak the electrode in distilled water for about 5 minutes to clean the membrane, rinse, and soak in standard solution for about 5 minutes.

Sample Requirements

- All samples must be aqueous and not contain organics which can dissolve in the membrane or extract out the liquid ion exchanger.

- The temperature of the standard solutions and of the sample solutions should be the same and below 40 °C. About a 2% error will be introduced for a 1 °C difference in temperature.

- Interference's should be absent. If they are present, use the procedures found in the **Interference**'s section to remove them.

- The pH range for the nitrate ion electrode is 2.5 - 11. Neutralize samples outside this range with acid or base to bring them in range.

Units of Measurement

Nitrate concentrations are measured in units of ppm as sodium nitrate, ppm as nitrate, moles per liter, or any other convenient concentration unit. Table 1 indicates some of the concentration units.

TABLE 1. Concentration Unit Conversion Factors

| *ppm NaNO$_3$*	*ppm NO$_3^{-1}$*	*moles/liter*
850.00	620.00	1.0×10^{-2}
85.0	62.0	1.0×10^{-3}
8.5	6.2	1.0×10^{-4}

Measurement Procedure

Direct Measurement

Direct measurement is a simple procedure for measuring a large number of samples. A single reading is all that is required for each sample. The ionic strength of samples and standards should be made the same by adjustment with ISA for all nitrate solutions. The temperature of both sample solution and standard solutions should be the same.

Direct Measurement

> ➤*Note: A calibration curve is constructed on semilogarithmic paper. The measured electrode potential (linear axis) is plotted against the standard concentration (log axis). In the <u>linear region of the curve, only two standards are necessary</u> to determine a calibration curve. Calibration solutions close to the anticipated value of the "unknown" should be chosen. In the <u>nonlinear region, additional points must be measured</u>. The direct measurement procedures given are for the linear portion of the curve. The nonlinear portion of the curve requires the use of low level procedures.*

1. By serial dilution, prepare three standard solutions from the 0.1 M or 1,000 ppm stock standard. The resultant concentrations should be 10^{-2}, 10^{-3}, and 10^{-4} M or 1,000, 100 and 10 ppm nitrate standards. Add 2 ml of ISA to each 100 ml of standard. Prepare standards with a composition similar to the samples if the samples have an ionic strength above 0.1 M

2. Place the most dilute solution (10^{-4} M or 10 ppm) in a 150 ml beaker on the magnetic stirrer and begin stirring at a constant rate. After assuring that *ScienceWorkshop* is operating, lower the electrode tip into the solution. After the reading has stabilized, record the Voltage reading in the Digits Display.

3. Place the mid-range solution (10^{-3}N or 100 ppm) in a 150 ml beaker on the magnetic stirrer and begin stirring. After rinsing the electrode with distilled water, blot dry and immerse the electrode tip in the solution. When the reading has stabilized, record the Voltage reading in the Digits Display.

4. Place the most concentrated solution (10^{-2} M or 1,000 ppm) in a 150ml beaker on the magnetic stirrer and begin stirring. After rinsing the electrode in distilled water, blot dry, and immerse the electrode tip in the solution. When the reading has stabilized, record the Voltage reading in the Digits Display.

5. Using the semi-logarithmic graph paper, plot the Voltage reading in the Digits Display (linear axis) against the concentration (log axis). Extrapolate the calibration curve down to about 1.0×10^{-5} M (1.0 ppm NO_3^{-1}). A typical calibration curve can be found in Figure 3.
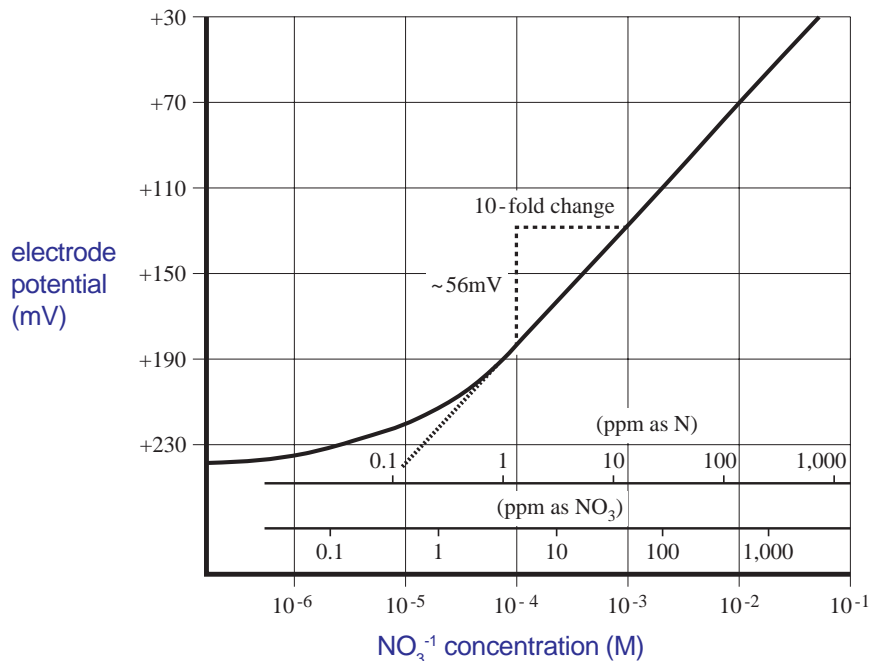
Figure 3
Typical nitrate electrode calibration curve

> ➤ *Note: A calibration curve is constructed on semi-logarithmic paper The measured electrode potential in (linear axis) is plotted against the standard concentration (log axis). In the linear region of the curve, only three standards are necessary to determine a calibration curve. In the non-linear region, additional points must be measured. The direct measurement procedures given are for the linear portion of the curve. The non-linear portion of the curve requires the use of low level procedures.*

6. To a clean, dry 150 ml beaker, add 100 ml of the sample and 2 ml of ISA. Place the beaker on the magnetic stirrer and begin stirring at a constant rate. Rinse the electrode tip with distilled water, blot dry, and lower the electrode tip into the solution. When the reading has stabilized, record the Voltage reading in the Digits Display. Using the calibration curve, determine the sample concentration.

7. The calibration should be checked every two hours. Assuming no change in ambient temperature, place the electrode tip in the mid-range standard. After the reading has stabilized, compare it to the original reading recorded in step 3 above. A reading differing by more than 0.5mV or a change in the ambient temperature will necessitate the repetition of steps 2 - 6 above. A new calibration curve should be prepared daily.

Low Level Nitrate Measurements

This procedure is recommended for solutions with ionic strengths less than 1.0×10^{-4} M. If the solution is high in ionic strength, but low in nitrate, use the same procedure, but prepare a calibration solution with a composition similar to the sample.

1. Using 20 ml of standard ISA, dilute to 100 ml with distilled water. This low level ISA [$0.4\,M\,(NH_4)_2SO_4$] is added at the rate of 1 ml low level ISA to each 100 ml of sample. The background ionic strength will be 4.0×10^{-3} M.

2. Dilute 1 ml of 0.1 M standard to 100 ml to prepare a 1.0×10^{-3} M NO_3^{-1} solution for measurements in moles per liter. Use the 1,000 ppm standard for preparing a 100 ppm NO_3^{-1} standard by diluting 10 ml of the 1,000 ppm standard to 100 ml. Standards should be prepared fresh daily.

3. Add 1 ml of the low level ISA to a 100 ml volumetric flask and fill to the mark with distilled water. Pour this solution into a 150 ml beaker and place the beaker on the magnetic stirrer. Begin stirring at a constant rate.

4. Place the electrode tip in the solution. Assure that *ScienceWorkshop* is operating.

5. Add increments of the 1.0×10^{-3} M or 100 ppm standards as given in Table 2 below.

6. After the reading has stabilized, record the Voltage reading in the Digits Display after each addition.

TABLE 2: Step-wise Calibration for Low Level Nitrate Measurements

Step	Pipette	Added Volume (mL)	Concentration M NO_3^{-1}	ppm NO_3^{-1}
1	A	0.1	1.0×10^{-6}	0.1
2	A	0.1	2.0×10^{-6}	0.2
3	A	0.2	4.0×10^{-6}	0.4
4	A	0.2	6.0×10^{-6}	0.6
5	A	0.4	9.9×10^{-6}	1.0
6	B	2.0	2.9×10^{-5}	2.9
7	B	2.0	4.8×10^{-5}	4.8

Pipette A = 1 ml graduated pipette
Pipette 8 = 2 ml pipette
Solutions: additions of 1.0×10^{-3} M or 100 ppm standard to 100 ml of ISA as prepared in step 3 above.

7. On semi-logarithmic graph paper, plot the voltage reading on the Digits display (linear axis) against the concentration (log axis) as in Figure 3.

8. Rinse the electrode and blot dry.

9. Measure out 100 ml of the sample into a 150 ml beaker, add 1 ml of low level ISA. Place the beaker on the magnetic stirrer and begin stirring. Lower the electrode tip into the solution. After the reading has stabilized, record the Voltage reading indicated in the Digits Display and determine the concentration from the low level calibration curve.

10. Prepare a new low level calibration curve daily. Check the calibration curve every two hours by repeating steps 2 - 7.

Electrode Characteristics

Reproducibility

Electrode measurements reproducible to +2% can be obtained if the electrode is calibrated every hour. Factors such as temperature fluctuations, drift, and noise limit reproducibility. Reproducibility is independent of concentration within the electrode's operating range.

Interferences

Certain anions are electrode interferences and will cause electrode malfunction, drift or measurement errors if present in high enough levels. The level of interfering common anions that will cause a 10% error at three levels of nitrate is given in Table 3.

TABLE 3:   Concentration of Possible Interference's Causing a 10% Error at Various Levels of Nitrate; Background Ionic Strength of 0.12 M $(NH_4)_2SO_4$.

Interference moles/liter	10^{-2} M	10^{-3} M	10^{-4} M
Cl^{-1}	3.0×10^{-1}	3.0×10^{-2}	3.0×10^{-3}
NO_2^{-1}	7.0×10^{-3}	7.0×10^{-4}	7.0×10^{-5}
Br^{-1}	7.0×10^{-3}	7.0×10^{-4}	7.0×10^{-5}
CN^{-1}	1.0×10^{-3}	1.0×10^{-4}	1.0×10^{-5}
ClO_3^{-1}	5.0×10^{-4}	5.0×10^{-5}	5.0×10^{-6}
I^{-1}	5.0×10^{-5}	5.0×10^{-6}	5.0×10^{-7}
ClO_4^{-1}	1.0×10^{-6}	1.0×10^{-7}	1.0×10^{-8}

Interference moles/liter	100 ppm N	10 ppm N	1 ppm N
Cl^{-1}	7,600	760	76.0
NO_2^{-1}	230	23.0	2.30
Br^{-1}	400	40.0	4.00
CN^{-1}	20.0	2.00	0.20
ClO_3^{-1}	30.0	3.00	0.30
I^{-1}	4.00	0.40	0.04
ClO_4^{-1}	0.07	0.007	0.0007

Interferences such as chloride, bromide, iodide and cyanide can be removed by precipitation with 0.5 grams of silver sulfate added to 100 ml of sample. Nitrite interference can be removed by adding 0.3 grams of sulfamic acid to 100 ml of sample. Carbonate and bicarbonate, which are weak interferences, can be removed by acidifying the sample to pH 4.5 with sulfuric acid. Organic (carboxylic) anions hinder the nitrate electrode response and can be removed by adding 10 grams of aluminum sulfate to 100 ml of sample.

The above interference removal procedures require similar treatment of standards as well as samples.

If the electrode is exposed to high levels of interfering ions which cannot be removed, the electrode reading may drift and the response may become sluggish. Restore performance by soaking in distilled water for 30 minutes followed by soaking in nitrate standard for 30 minutes.

Temperature Influences

Samples and standards should be at the same temperature, since electrode potentials are influenced by changes in temperature. A 1 °C difference in temperature results in a 2% error at the 10^{-3} M level. Because of the solubility equilibria on which the electrode depends, the absolute potential of the reference electrode changes slowly with temperature. The slope of the nitrate electrode, as indicated by the factor "S" in the Nernst equation, also varies with temperature. Table 4 gives values for the "S" factor in the Nernst equation for the nitrate ion.

The operating range of the nitrate ion electrode is 0 °C - 40 °C, provided that temperature equilibrium has occurred.

If the temperature varies substantially from room temperature, equilibrium times up to one hour are recommended.

TABLE 4: Temperature vs. Theoretical Values for the Electrode Slope

Temperature (°C)	"S"
0	54.20
10	56.18
20	58.16
25	59.16
30	60.15
40	62.13
50	64.11

Electrode Response

Plotting the electrode potential against the nitrate concentration on semi-logarithmic paper results in a straight line with a slope of about 55 mV/decade. (Refer to Figure 3.)

The time needed to reach 99% of the stable electrode potential reading, the electrode response time, varies from one minute or less in highly concentrated solutions to several minutes near the detection limit. (Refer to Figure 4.)
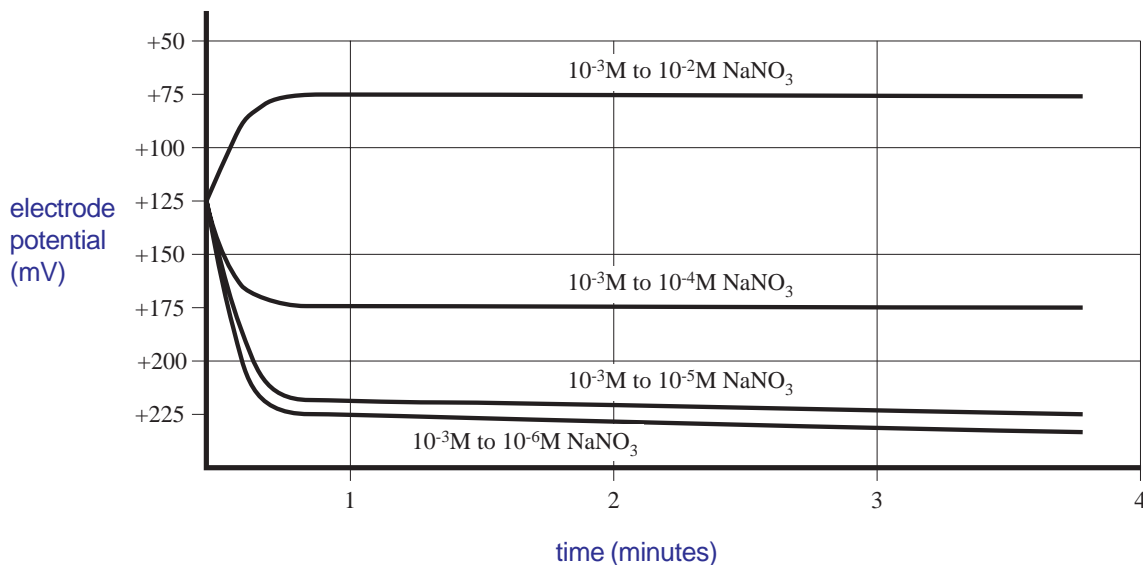
Figure 4
Typical electrode time response to step changes in NaNO3

Limits of Detection

The upper limit of detection in pure sodium nitrate solutions is 1 M. In the presence of other ions, the upper limit of detection is above 10^{-1} M nitrate, but two factors influence this upper limit. Both the possibility of a liquid junction potential developing at the reference electrode and the malt extraction effect influence this upper limit. Some salts may infuse into the electrode membrane at high salt concentrations, causing deviation from the theoretical response. Either dilute samples between 1 M and 10^{-1} M or calibrate the electrode at 4 or 5 intermediate points.

The lower limit of detection is influenced by the slight water solubility of the ion exchanger used in the sensing portion of the electrode. Refer to Figure 3 for a comparison of the theoretical response to the actual response at low levels of nitrate. Nitrate measurements below 10^{-5} M NO_3^{-1} (0.6 ppm as NO_3^{-1}) should employ low level procedures.

pH Effects

The operating range of the nitrate electrode is from pH 2.5 to pH 11.

Electrode Life

The nitrate electrode will last six months in normal laboratory use. On-line measurement might shorten operational lifetime to several months. In time, the response time will increase and the calibration slope will decrease to the point calibration is difficult and electrode replacement is required.

Maintenance

Electrode Storage

The nitrate electrode may be stored for short periods of time in 10^{-2} M nitrate solution. For longer storage (longer than two weeks), rinse and dry the nitrate membrane and cover the tip with any protective cap shipped with the electrode. The reference portion of the combination electrode (or the outer chamber of the reference electrode) should be drained of filling solution, if refillable and the rubber insert placed over the filling hole.

Specifications

Concentration Range:	1 M to $7X10^{-6}$ M ($6.2X10^4$ to 0.5 ppm as NO_3^{-1})
pH Range:	2.5 to 11
Temperature Range:	0 °C – 40 °C
Resistance:	100M ohms
Reproducibility:	±2%
Samples:	aqueous solutions only, no organic solvents
Storage:	store in dilute nitrate solution
Size:	110 mm length
	12 mm diameter
	cable length = 1 m

Troubleshooting Guide

The goal of troubleshooting is the isolation of a problem through checking each of the system components in turn: the meter, the plastic-ware, the electrode, the standards & reagents, the sample, and the technique.

Glassware/Plastic-ware

Clean glassware is essential for good measurement. Be sure to wash the glassware/plastic-ware well with a mild detergent and rinse very well with distilled or deionized water.

Electrode

The electrode may be checked by using the procedure found in the sections entitled *Electrode Slope Check*.

1. Be sure to use distilled or deionized water when following the procedures given in *Electrode Slope Check*.

2. If the electrode fails to respond as expected, see the section *Measuring Hints*. Repeat the slope check.

3. If the electrode still fails to respond as expected, substitute another Nitrate Ion Selective Electrode (if available) that is known to be in good working order for the questionable electrode. If the problem persists and you are using an electrode pair, try the same routine with a working reference electrode.

4. If the problem persists, the standards or reagent may be of poor quality, interferences in the sample may be present or the technique may be faulty. (See *Standards Reagents*, *Sample*, and *Technique* sections below.)

5. If another electrode is not available for test purposes, or if the electrode in use is suspect, review the instruction manual and be sure to:

    - Clean and rinse the electrode thoroughly.

    - Prepare the electrode properly.

    - Use the proper filling solution.

    - Adjust the pH and the ionic strength of the solution by the use of the proper ISA.

    - Measure correctly and accurately.

    - Review *Troubleshooting Hints*.

Standards & Reagents

Whenever problems arise with the measuring procedure that has been used successfully in the past, be sure to check the standard and reagent solutions. If in doubt about the credibility of any of the solutions, prepare them again. Errors may result from contamination of the ISA, incorrect dilution of standards, poor quality distilled/deionized water, or a simple mathematical miscalculation.

Sample

Look for possible interferences, complexing agents, or substances which could affect the response or physically damage the sensing electrode if the electrode works perfectly in the standard, but not in the sample.

Try to determine the composition of the samples prior to testing to eliminate a problem before it starts. (See *Measuring Hints*, *Sample Requirements*, and *Interferences*.)

Technique

Be sure that the electrode's limit of detection has not been exceeded. Be sure that the analysis method is clearly understood and is compatible with the sample. Refer to the instruction manual again. Reread *General Preparation* and *Electrode Characteristics*.

If trouble still persists, call PASCO scientific Technical Support.

Troubleshooting Hints

Symptom	Possible Causes	Next Step
Out of Range Reading	defective electrode	check electrode operation
	electrodes not plugged in properly	unplug electrodes and reseat electrodes
	reference electrode not filled	be sure reference electrode is filled
	air bubble on membrane	remove bubble by re-dipping electrode
	electrode not in solution	put electrodes in solution
Noisy or Unstable Readings (readings continuously or rapidly changing)	electrode exposed to interferences	soak electrode in nitrate standard
	defective electrode	replace electrode
	ISA not used	use recommended ISA
	stirrer not grounded	ground stirrer
	air bubble on membrane	remove bubble by re-dipping electrode
	outer filling solution level too low	fill electrode to level just below the fill hole
Drift (reading slowly changing in one direction)	samples and standards at different temperatures	allow solutions to come to room temperature before measurement
	electrode exposed to interferences	soak electrode in nitrate standard
	incorrect reference filling solution	use recommended filling solution

Symptom	Possible Causes	Next Step
Low Slope or No Slope	standards contaminated or incorrectly made	prepare fresh standards
	ISA not used	use recommended ISA
	standard used as ISA	use ISA
	electrode exposed to interferences	soak electrode in nitrate standard
	defective electrode	check electrode operation
	air bubble on membrane	remove bubble by re-dipping probe
"Incorrect Answer" (but calibration curve is good)	incorrect scaling of semilog paper	plot voltage potential on the linear axis. On the log axis, be sure concentration numbers within each decade are increasing with increasing concentration.
	incorrect sign	be sure to note sign of millivolt reading correctly
	incorrect standards	prepare fresh standards
	wrong units used	apply correct conversion factor: 10^{-3} M = 62.0 ppm as NO_3^{-1} 10^{-3} M = 85.0 ppm as $NaNO_3$
	sample carryover	rinse electrode thoroughly between samples

Technical Support

Feedback

If you have any comments about the product or manual, please let us know. If you have any suggestions on alternate experiments or find a problem in the manual, please tell us. PASCO appreciates any customer feedback. Your input helps us evaluate and improve our product.

To Reach PASCO

For technical support, call us at 1-800-772-8700 (toll-free within the U.S.) or (916) 786-3800.

fax: (916) 786-3292

e-mail: techsupp@pasco.com

web: www.pasco.com

Contacting Technical Support

Before you call the PASCO Technical Support staff, it would be helpful to prepare the following information:

➤ If your problem is with the PASCO apparatus, note:

- Title and model number (usually listed on the label);
- Approximate age of apparatus;
- A detailed description of the problem/ sequence of events (in case you can't call PASCO right away, you won't lose valuable data);
- If possible, have the apparatus within reach when calling to facilitate description of individual parts.

➤ If your problem relates to the instruction manual, note:

- Part number and revision (listed by month and year on the front cover);
- Have the manual at hand to discuss your questions.