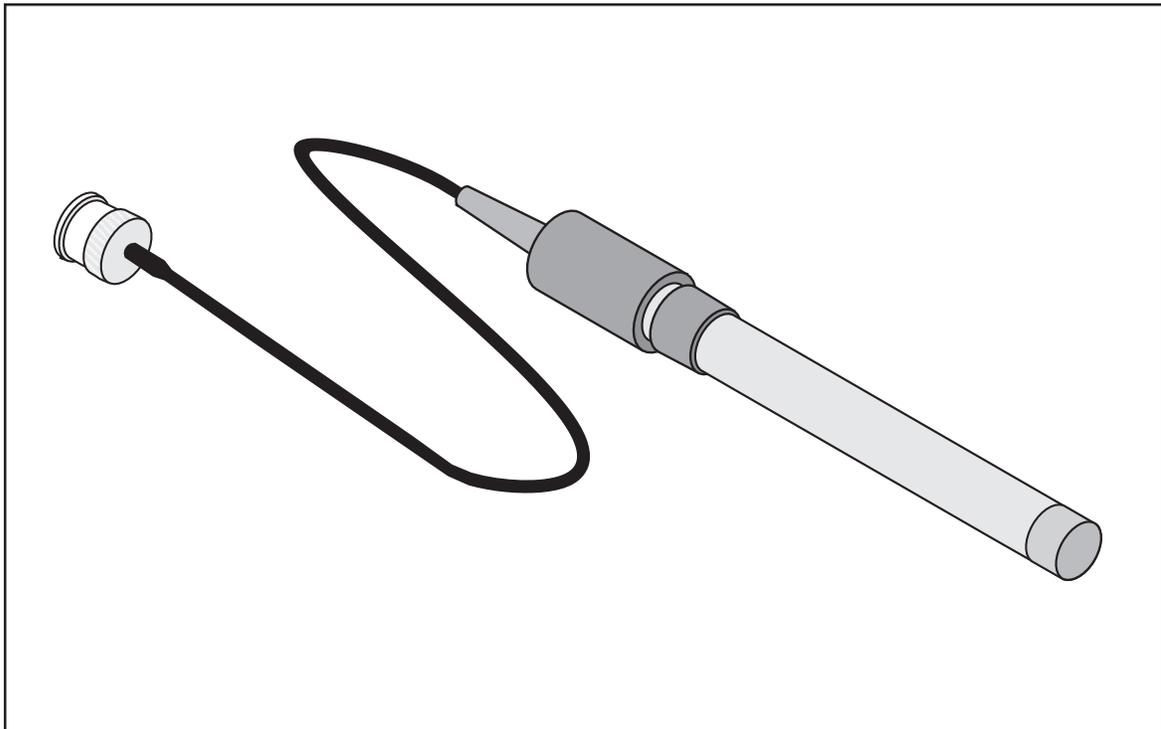


**Instruction Manual and  
Experiment Guide for the  
PASCO scientific  
Model CI-6734**

012-06615A  
9/97

# **SODIUM ION SELECTIVE ELECTRODE**



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\$7.50



**Always use eye protection  
and gloves when working  
with chemicals.**

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## Introduction

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

## Theory

The Sodium Ion Selective Electrode is composed of a sodium-selective glass membrane bonded to a glass body. When the membrane is in contact with a solution containing sodium ions, an electrode potential develops across the membrane. This electrode potential is measured against a constant reference potential, using an ISE Amplifier and a *ScienceWorkshop* computer interface. The level of sodium ions, corresponding to the measured potential, is described by the Nernst equation.

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

where:

$$\begin{aligned} E &= \text{measured electrode potential} \\ E_0 &= \text{reference potential (a constant)} \\ S &= \text{electrode slope } (\approx 59 \frac{\text{mV}}{\text{decade}}) \\ X &= \text{level of sodium ions in solution} \end{aligned}$$

The activity,  $X$ , represents the effective concentration of free sodium ions in the solution. The activity is related to the free ion concentration,  $C_f$ , by the activity coefficient,  $\gamma$  by:

$$X = \gamma C_f$$

Activity coefficients may vary, depending on the total ionic strength,  $I$ , determined as:

$$I = \frac{1}{2} \sum C_x Z_x^2$$

where:

$$\begin{aligned} C_x &= \text{concentration of ion } X \\ Z_x &= \text{charge of ion } X \\ \Sigma &= \text{sum of all of the types of ions in the solution} \end{aligned}$$

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

To adjust the background ionic strength to a high and constant value, ionic strength adjuster is added to samples and standards. The recommended ISA for sodium is an ammonium chloride/ammonium hydroxide buffer. 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 sodium ions.

## Equipment

### Included:

- Sodium Ion Selective Electrode
- Sodium Ion Selective Electrode fill solution
- pipette for fill solution

### Additional Required:

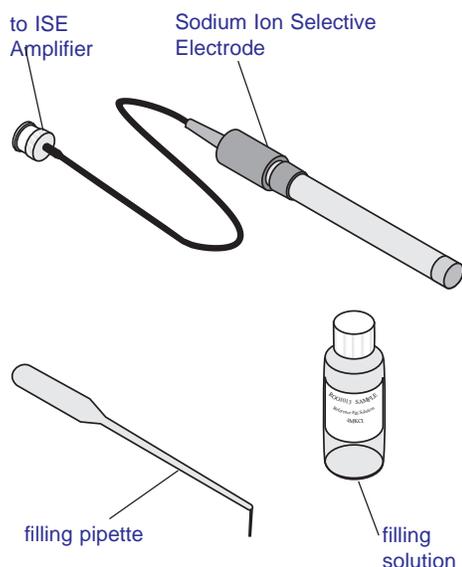
#### Required Equipment

- PASCO CI-6738 ISE (Ion Selective Electrode) Amplifier
- *Science Workshop 2.2.5* or higher
- PASCO *Science Workshop* Computer Interface
- Semilogarithmic 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 described 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), 4 M NH<sub>4</sub>Cl/4 M NH<sub>4</sub>OH*  
To prepare this solution, half fill a 1000 ml volumetric flask with distilled water and add 214 grams of reagent-grade ammonium chloride (NH<sub>4</sub>Cl). Under a hood, add 270 ml of concentrated ammonium hydroxide (NH<sub>4</sub>OH), swirl the flask gently to dissolve the solid, and allow to cool. Fill the flask to the mark with distilled water, cap, and upend several times to mix the solution.
- *Sodium Electrode Storage Solution, 5 M NaCl*  
To prepare this solution, add 29.2 grams of reagent-grade sodium chloride (NaCl) to 100 ml of distilled water. To each 100 ml storage solution, add 2 ml of ISA.



**Figure 1.**  
Included Equipment



► **Note: Electrodes must not be stored in distilled water or air. Do not rinse with distilled water.**

- *Dilute Electrode Rinse Solution*

To prepare this solution from your own laboratory stock, add 20 ml of ISA to a one liter volumetric flask and fill to the mark with distilled water. Use this solution to rinse the electrode between measurements.

- *Sodium Standard, 0.1 M NaCl*

To prepare this solution, half fill a one liter volumetric flask with distilled water and add 5.84 grams of reagent-grade NaCl. 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 solution.

- *Sodium Standard, 1,000 ppm Na<sup>+</sup>*

To prepare this solution, half fill a one liter volumetric flask with distilled water and add 2.542 grams of reagent grade NaCl. 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 solution.

- *Sodium Standard, 100 ppm Na<sup>+</sup>*

To prepare this solution, half fill a one liter volumetric flask with distilled water and add 0.254 grams of reagent grade NaCl. Swirl the flask to dissolve the solid. Fill the flask to the mark with distilled water, cap, and upend several times to mix the solution.

## General Preparation

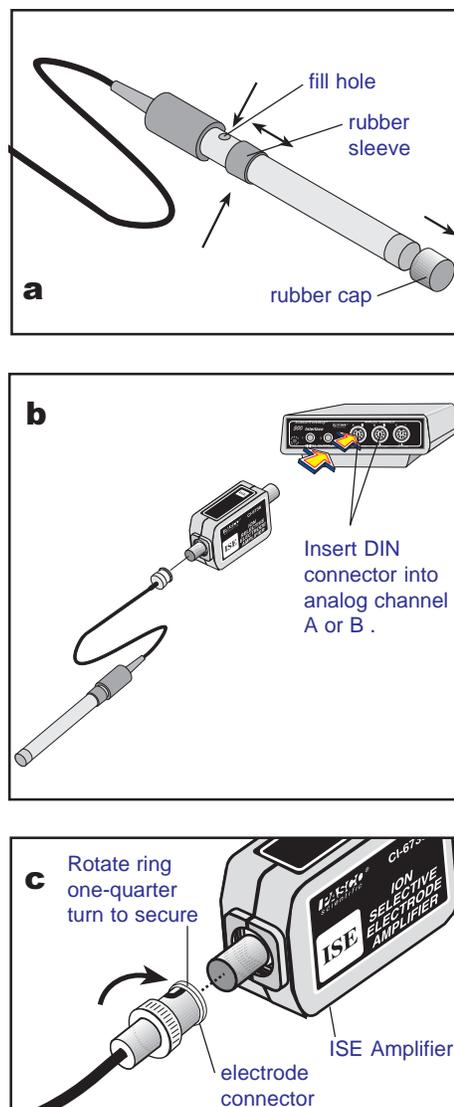
### Electrode Preparation

1. Remove the rubber cap covering the electrode tip and the rubber insert covering the filling hole of the Sodium Ion Selective Electrode. Fill the electrode with the included filling solution to a level just below the fill hole. No preparation is required with a sealed reference electrode.
2. Connect the Sodium Ion Selective Electrode to the ISE Amplifier and insert the DIN connector of the ISE Amplifier into analog channel A or B on a PASCO Computer Interface (Figures 2b and 2c).

### Electrode Slope Check Using ScienceWorkshop (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 sodium standard to the beaker. When the reading has stabilized, record the voltage reading indicated in the Digits display.
3. Using a pipette, add 10 ml of the same sodium 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  $59 \pm 4\text{mV}$  indicates correct electrode operation assuming the solution temperature is between  $20\text{ }^{\circ}\text{C}$  and  $25\text{ }^{\circ}\text{C}$ . 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.



**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

## Measurement

### Measuring Hints

- All samples and standards should be at the same temperature for precise measurement, preferably ambient temperature. A difference of 1 °C in temperature will result in about a 2% measurement error. The electrodes should not be used above 70 °C.
- 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 a styrofoam sheet, between the stirrer and the beaker.
- Always rinse the electrodes with electrode rinse solution from a wash bottle between measurements. Use a clean, dry tissue to prevent cross contamination. Never use distilled water.
- Store the electrodes in electrode storage solution between measurements. Do not store in air or distilled water. Always soak new electrodes overnight in electrode storage solution prior to first use. When making low level sodium measurements, use a dilute sodium chloride storage solution. Add 1 ml of ISA to 100 ml of dilute storage solution.
- Plastic lab-ware should be used for low level measurements (< 1 ppm).
- All measurements should be made in basic solution. All samples and standards should be adjusted to a pH > 9 with ISA.
- 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.

### Sample Requirements

- The sample measuring range is pH 9–12. Use the ISA recommended to adjust the pH for best accuracy. Make sure that the samples and standards are at the same temperature. The glass electrode sensing bulb will not be attacked by most organic solvents.

### Units of Measurement

Sodium concentrations are measured in units of parts per million, equivalents per liter, moles per liter, or any other convenient concentration unit. Table 1 indicates some of the concentration unit conversion factors.

**TABLE 1**      **Concentration Unit Conversion Factors**

<i>ppm Na<sup>+</sup></i>	<i>moles/liter Na<sup>+</sup></i>
229.90	1.0 X 10 <sup>-2</sup>
22.99	1.0 X 10 <sup>-3</sup>
2.30	1.0 X 10 <sup>-4</sup>

## Measurement Procedure

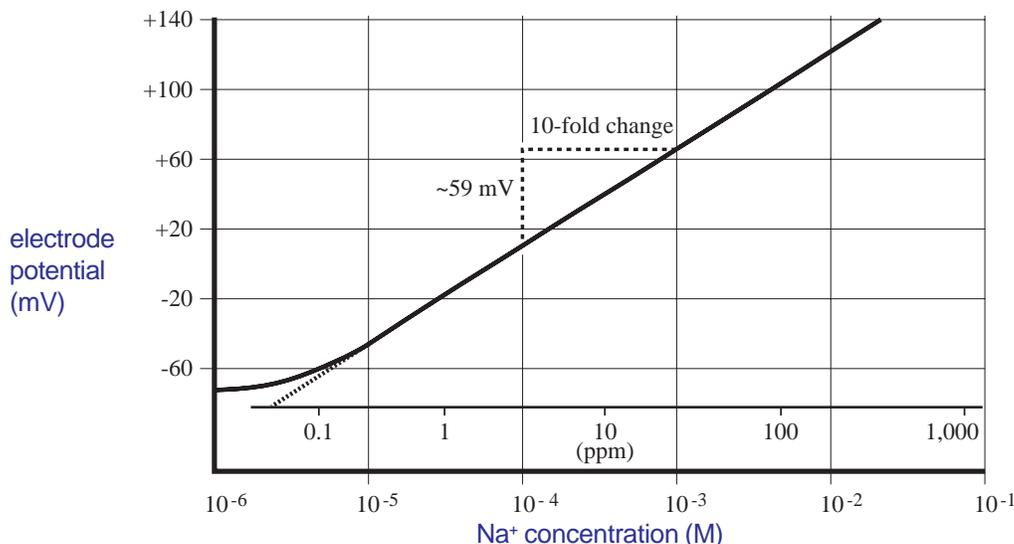
### Direct Measurement

Direct measurement is a simple procedure for measuring a large number of samples. A single meter 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 sodium solutions. The temperature of both sample solution and of standard solutions should be the same.

#### Direct Measurement of Sodium

► **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 linear region of the curve, only two standards are necessary to determine a calibration curve. Calibration solutions close to the anticipated value of the “unknown” should be chosen. In the nonlinear region, additional points must be measured. 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 of the 0.1 M or 1,000 ppm standards, prepare 100 ml of  $10^{-2}$  M,  $10^{-3}$  M, and  $10^{-4}$  M or 100 and 10 ppm sodium standards. Add 2 ml of ISA per 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 beaker. Place the 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. When the reading has stabilized, record the voltage reading indicated in the Digits display.
3. Place the mid-range solution ( $10^{-3}$  M or 100 ppm) in a beaker. Place the beaker on the magnetic stirrer and begin stirring. After rinsing the electrodes with electrode rinse solution, blot dry and immerse the electrode tip in the solution. When the reading has stabilized, record the voltage reading indicated in the Digits display.
4. Place the most concentrated solution ( $10^{-2}$  M or 1,000 ppm) in a beaker. Place the beaker on the magnetic stirrer and begin stirring. After rinsing the electrodes with electrode rinse solution, blot dry and immerse the electrode tip in the solution. When the reading has stabilized, record the voltage reading indicated in the Digits display.
5. Using the semilogarithmic graph paper, plot the voltage reading (linear axis) against the concentration (log axis). Extrapolate the curve down to about  $5.0 \times 10^{-5}$  M. For measurements below this level, follow the instructions for low-level measurement. A typical calibration curve can be found in Figure 3.



**Figure 3**  
Typical sodium electrode calibration curve

- To a clean, dry 150 ml beaker, add 100 ml of sample and 2 ml of ISA. Place the beaker on the magnetic stirrer and begin stirring. After rinsing the electrode tip with electrode rinse solution, blot dry and place the electrode tip in the solution. When the reading has stabilized, record the Voltage reading in the Digits Display. Using the calibration curve, determine the sample concentration.
- 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 difference by more than 0.5 mV or a change in the ambient temperature will necessitate the repetition of steps 2-5 above. A new calibration curve should be prepared daily.

### Low Level Sodium Determination

This procedure is recommended for solutions with ionic strength less than  $1.0 \times 10^{-2}$  M and a sodium concentration less than  $1 \times 10^{-5}$  M or 1 ppm. If the solution is high in ionic strength, but low in sodium, use the same procedure, but prepare a calibration solution with a composition similar to the sample. Use plastic lab-ware for low sodium measurements.

- Using 20 ml of standard ISA, dilute to 100 ml with distilled water.
- Dilute 20 ml of the outer chamber filling solution to 100 ml with distilled water and fill the reference electrode if using a double junction reference electrode.
- Dilute 1 ml of the 0.1 M standard to 100 ml to prepare a  $1.0 \times 10^{-3}$  M standard solution for measurements in moles per liter. Dilute 10 ml of the 1000 ppm standard solution to 100 ml to prepare a 100 ppm standard solution for measurements in ppm. Add 1 ml of low level ISA to each 100 ml of standard. Standards should be prepared fresh daily.
- Using a 150 ml plastic beaker, add 100 ml of distilled water and 1 ml of low level ISA. Add  $\text{NH}_4\text{OH}$ , if necessary, to adjust the pH above 9. Place the beaker on the magnetic stirrer and begin stirring at a constant rate.
- Place the electrode tip in the solution. Assure that *ScienceWorkshop* is operating.

6. Add increments of the  $1.0 \times 10^{-3}$  M or 100 ppm standard as given in Table 2 below.
7. After the reading has stabilized, record the Voltage reading in the Digits display after each addition.

**TABLE 2: Step-wise Calibration for Low Level Sodium Measurements**

Step	Pipette	Added Volume (ml)	Concentration	
			ppm	M
1	A	0.1	0.10	$1.0 \times 10^{-6}$
2	A	0.1	0.20	$2.0 \times 10^{-6}$
3	A	0.2	0.40	$4.0 \times 10^{-6}$
4	A	0.2	0.60	$6.0 \times 10^{-6}$
5	A	0.4	0.99	$9.9 \times 10^{-6}$
6	B	2.0	2.91	$2.9 \times 10^{-5}$
7	B	2.0	4.76	$4.8 \times 10^{-5}$

Pipette A = 1 ml graduated pipette

Pipette B = 2 ml pipette

Solutions: additions of 100 ppm or  $1.0 \times 10^{-3}$  M standard to 100 ml of solution prepared in step 3 above

8. On semilogarithmic graph paper, plot the millivolt reading (linear axis) against the concentration (log axis) as in Figure 3.
9. Rinse the electrodes with electrode rinse solution and blot dry.
10. To a 150 ml plastic beaker add 100 ml of sample and 1 ml of low level ISA. Place the beaker on the magnetic stirrer and begin stirring. Adjust the pH, if necessary, to above 9. Lower the electrode tip into the solution. After the reading has stabilized, record the Voltage reading in the Digits Display and determine the concentration from the low level calibration curve.
11. Prepare a new low level calibration curve daily. Check the calibration curve every two hours by repeating steps 3-8.

## 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

Table 3 lists some common cations that, if present in high enough levels, will cause electrode interferences and measurement errors or electrode drift when using the sodium ion electrodes.

Most samples do not contain or contain very little of the cations shown in Table 3. The ammonium ion ( $\text{NH}_4^+$ ), found in the recommended ISA, will not result in an error if all samples and standards have the same level of ISA present.

Electrode drift and slow response could indicate the presence of high interference from the ions listed. Soak the electrodes in electrode storage solution when this happens to restore proper response. See *Measuring Hints* section.

**TABLE 3: Levels of Interfering Ions Resulting in a 10% Error at Specified Levels of Sodium**

<b>Interference</b>	<b>1.0X10<sup>-4</sup> M</b>	<b>1.0X10<sup>-3</sup> M</b>	<b>1.0X10<sup>-2</sup> M</b>
Li <sup>+1</sup>	5X10 <sup>-4</sup> M	5X10 <sup>-3</sup> M	5X10 <sup>-2</sup> M
K <sup>+1</sup>	1X10 <sup>-2</sup> M	1X10 <sup>-1</sup> M	1 M
Rb <sup>+1</sup>	3X10 <sup>-1</sup> M	3 M	–
NH <sub>4</sub> <sup>+1</sup>	3X10 <sup>-1</sup> M	3 M	–
Ag <sup>+1</sup>	3X10 <sup>-9</sup> M	3X10 <sup>-8</sup> M	3X10 <sup>-7</sup> M
Tl <sup>+1</sup>	5X10 <sup>-2</sup> M	5X10 <sup>-1</sup> M	–

<b>Interference</b>	<b>1 ppm</b>	<b>10 ppm</b>	<b>100 ppm</b>
Li <sup>+1</sup>	1.5 ppm	15 ppm	150 ppm
K <sup>+1</sup>	17 ppm	170 ppm	1,700 ppm
Rb <sup>+1</sup>	1.1X10 <sup>4</sup> ppm	1.1X10 <sup>5</sup> ppm	–
NH <sub>4</sub> <sup>+1</sup>	1.8X10 <sup>3</sup> ppm	1.8X10 <sup>4</sup> ppm	–
Ag <sup>+1</sup>	0.0001 ppm	0.001 ppm	0.01 ppm
Tl <sup>+1</sup>	4.5X10 <sup>3</sup> ppm	4.5X10 <sup>4</sup> ppm	–

### 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<sup>-3</sup> M level. Because of solubility equilibria on which the electrode depends, the absolute potential of the reference electrode changes slowly with temperature. The slope of the electrode, as indicated by the factor “S” in the Nernst equation, also varies with temperature. Table 4 indicates the variation of theoretical slope with temperature.

Provided that temperature equilibria has occurred, the sodium ion electrodes can be used at temperatures from -5 ° to 70 °C. Room temperature measurements are recommended, since measurements at temperatures markedly different from room temperature may require equilibrium times up to one hour. The electrode should not be used at temperatures above 70 °C, since damage to the membrane may result.

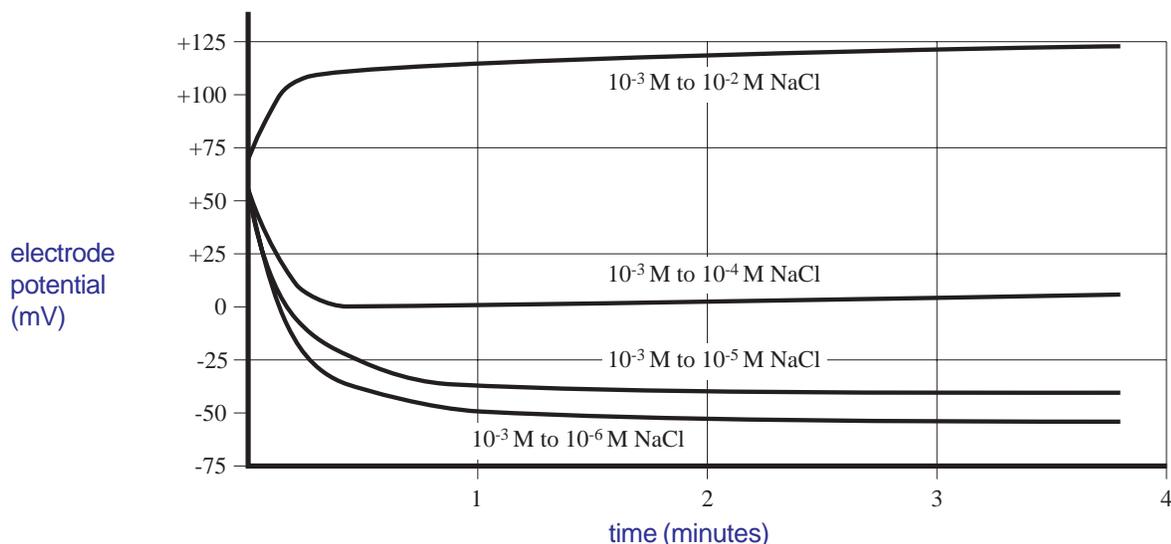
**TABLE 4: Temperature vs. Values for the Electrode Slope**

<i>Temperature (°C)</i>	<i>“S”</i>
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 sodium concentration on semilogarithmic paper results in a straight line with a slope of about 59 mV per decade. (Refer to Figure 1.)

The time needed to reach 99% of the stable electrode potential reading, the electrode response time, varies from one minute or less for sodium concentrations above  $1.0 \times 10^{-5}$  M to several minutes near the detection limit. (Refer to Figure 4.)



**Figure 4**  
Typical sodium electrode time response to step changes in NaCl

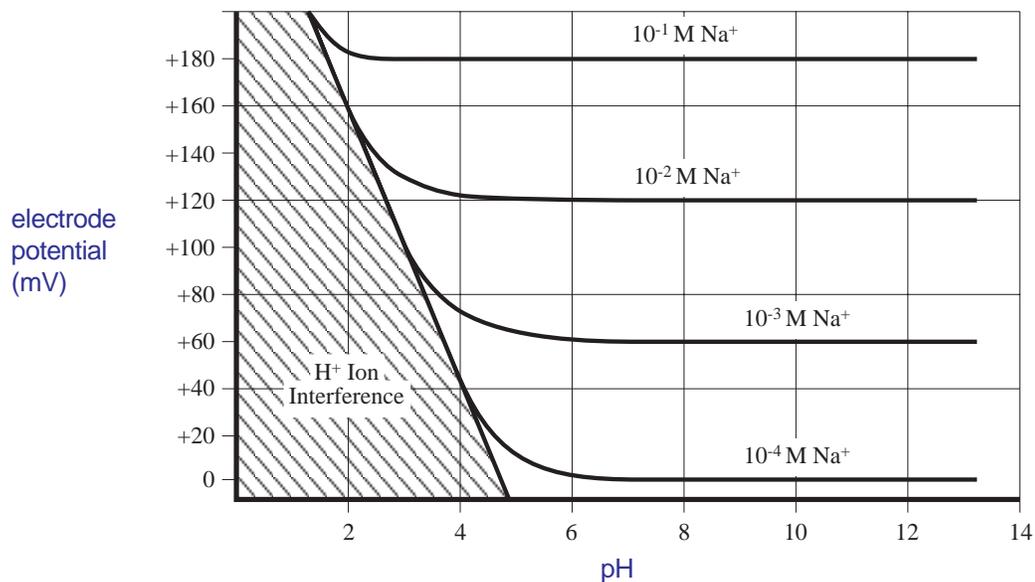
## Limits of Detection

The upper limit of detection in pure sodium solutions is 1 M. In the presence of other ions, the upper limit of detection is above  $10^{-1}$  M sodium, but two factors influence this upper limit. Both the possibility of a liquid junction potential developing at the reference electrode and the salt extraction effect influence this upper limit. Some salts may extract 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.

Free sodium ion concentration down to  $1.0 \times 10^{-6}$  M or 0.1 ppm can be measured in basic solutions. For measurements below  $10^{-5}$  M or 1 ppm, use plastic lab-ware (and low level procedures) since a significant pickup of sodium may occur from glassware due to removal from container walls.

## pH Effects

The electrode response to sodium ions is greatly influenced by the pH of the solution. Hydrogen ion interferes with measurements of low level sodium ion measurements, although the electrode can be used over a wide pH range. (See Figure 5.)



**Figure 5**

Electrode potential behavior vs. solution pH in pure NaCl solution at 25 °

The edge of the shaded area (the straight line) shown in Figure 5 indicates a minimum pH at which dilute sodium measurements can be made with less than 10% hydrogen ion interference.

The pH should be adjusted to a pH greater than 9 by the addition of ISA to all standards and samples for optimal results over the entire concentration range of sodium. Additional ammonium hydroxide may be necessary to adjust the pH to the desired level in some cases.

## Electrode Life

The sodium electrode will last six months in normal laboratory use. On-line measurements 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 Sodium Ion Selective Electrode should be stored in the sodium electrode storage solution, never in air or in distilled water. A more dilute sodium chloride solution (with pH adjusted through the use of ISA) may be used for storage before low level measurements. For longer storage (longer than two weeks), rinse and dry the sensing glass and cover the glass 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:	Saturated to $1.0 \times 10^{-6}$ M (0.02 ppm)
pH Range:	5 to 12 (depending on pH level)
Temperature Range:	-5 °C – 70 °C
Resistance:	< 200 mohm
Reproducibility:	±2%
Storage:	store in 5 M NaCl with added ISA
Size:	length = 110 mm diameter = 12 mm 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 glassware, the electrodes, the standards and 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. Clean glassware will drain without leaving water droplets behind.

### Electrode

The electrodes 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 sections *Measuring Hints* and *Electrode Response*. Repeat the slope check.
3. If the electrode still fails to respond as expected, substitute another Sodium Ion Selective Electrode (if available) that is known to be in good working order for the questionable electrode.
4. If the problem persists, the 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(s) 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 (or the reference electrode) if the electrodes work 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 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 reseal electrodes
	reference electrode not filled	replenish reference filling solution
	electrodes not in solution	put electrodes in solution
	air bubble on membrane	remove bubble by re-dipping electrode

Symptom	Possible Causes	Next Step
Noisy or Unstable Readings (readings continuously or rapidly changing)	electrode exposed to interferences	soak overnight in electrode storage solution
	defective electrode	replace electrode
	ISA not used	use recommended ISA
	stirrer not grounded	ground stirrer
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 overnight in electrode storage solution
	incorrect reference filling solution	use recommended filling solution
	pH too acidic	adjust pH with ISA
	ISA not used	use recommended ISA
Low Slope or No Slope	standards contaminated or incorrectly made	prepare fresh standards
	standard used as ISA	use ISA
	electrode exposed to interferences	soak overnight in electrode storage solution
	pH too acidic	adjust pH with ISA
	air bubble on membrane	remove bubble by re-dipping probe

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Symptom	Possible Causes	Next Step
“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: $1.0 \times 10^{-3} \text{ M} = 23.0 \text{ ppm as Na}^{+1}$
	sample pH too acidic	adjust pH with ISA

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# 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](mailto:techsupp@pasco.com)

web: [www.pasco.com](http://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.

