

1. Specifications

Concentration Range: Saturated to $1.0 \times 10^{-6}\text{M}$ (0.02 ppm)

pH Range: 5 to 12 (depending on Na^+ level) **Temperature Range:** $0^\circ - 70^\circ\text{C}$

Resistance: < 200 Mohm **Reproducibility:** $\pm 2\%$

Size: 110 mm l x 12 mm dia; 1 m cable length **Storage :** store in 5M NaCl with added ISA

2. General instructions

The Cole-Parmer® Sodium Electrodes are used to quickly, simply, accurately, and economically measure sodium ion concentrations in aqueous solutions.

Required Equipment

1. A pH/mV meter (0.1mV resolution) or an ion meter, either line operated or portable.
2. Semi-logarithmic 4-cycle graph paper for preparing calibration curves when using the meter in the mV mode.
3. A magnetic stirrer.
4. Cole-Parmer® Sodium Combination Epoxy Body Electrode, catalog number 27502-42, or the Cole-Parmer® Sodium Combination Glass Body Electrode, catalog number 27502-43.
5. Syringe to fill the electrode. A syringe is included with the electrode, but if it is not, you will need another dispensing device to fill the electrode.
6. Labware made of plastic, not glass. You will need a variety of beakers and graduated cylinders for measurements.

Required Solutions

1. Deionized or distilled water for solution and standard preparation.
2. Cole-Parmer® Electrode filling solution, catalog number 27503-76 for the Sodium Combination Epoxy Body Electrode 27502-42 or Cole-Parmer® Electrode Filling Solution, catalog number 27503-82, for the Sodium Combination Glass Body Electrode 27502-43.
3. Cole-Parmer® Standard Solutions - either 0.1M or 1000 ppm. Purchase or prepare the standard solution based on the unit of measure you want your results to be in, either molarity (0.1M) or parts per million (ppm):
 - A. Cole-Parmer® Sodium Standard, 0.1M NaCl, catalog number 27503-33.
To prepare this solution from your own laboratory stock, half fill a 1 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 the flask and invert several times to mix the solution.
 - B. Cole-Parmer® Sodium Standard, 1000 ppm Na^+ , catalog number 27503-34.
To prepare this solution from your laboratory stock, half fill a 1 liter volumetric flask with distilled water and add 2.542 grams of reagent grade NaCl. Swirl the flask to dissolve the solid. Fill the flask to the mark with distilled water.
4. Cole-Parmer® Ionic Strength Adjuster (ISA), 4M $\text{NH}_4\text{Cl}/4\text{M}$ NH_4OH , catalog number 27503-54.
To prepare this solution from your own laboratory stock, add 214 grams of reagent grade ammonium chloride (NH_4Cl) to a 1000 ml volumetric flask about half full of distilled water. Add 270 ml of concentrated ammonium hydroxide (NH_4OH) under a hood, swirl to dissolve, allow to cool and dilute to the mark with distilled water. Cap the flask and invert several times to mix the solution.
5. 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 dilute to the mark with distilled water. Use this solution to rinse the electrode between measurements. DO NOT rinse with distilled water.
6. Sodium Standard, 100 ppm Na^+ . To prepare this solution from your own laboratory stock, half fill a 1 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.

7. Sodium Electrode Storage Solution, 5 M NaCl. To prepare this solution from your own laboratory stock, add 29.2 grams of reagent grade sodium chloride (NaCl) to 100ml of distilled water. To each 100 ml storage solution, add 2 ml of ISA. DO NOT STORE ELECTRODES IN DISTILLED WATER OR AIR.

3. General Preparation

Electrode Preparation

Remove the rubber cap covering the electrode tip and the rubber insert covering the filling hole of the electrode. Fill the combination electrode with the filling solution shipped with the electrode to a level just below the fill hole. Connect the electrode to the proper meter terminal as instructed by the meter instructions. Soak the sodium electrode tip overnight in the electrode storage solution.

Electrode Slope Check (with standard pH/mV meter)

1. Add 100 ml of distilled water and 2 ml of ISA to a 150 ml beaker. Place the beaker on a magnetic stirrer and stir at a constant rate. Make sure the meter is in the mV mode, and lower the electrode tip into the solution.
2. Using a pipet, add 1 ml of 0.1M or 1000 ppm sodium standard to the beaker. When the reading stabilizes, record the millivolt reading.
3. Using a pipet, add 10 ml of the standard used above to the beaker. When the reading stabilizes, record the millivolt reading.
4. Determine the difference between the two readings. A difference of 56 ± 2 mV indicates correct electrode operation, assuming the solution temperature is between 20° and 25°C. See "Troubleshooting Hints", Addendum 1 if the potential change is not within this range.

Slope is defined as the change in potential observed when the concentration changes by a factor of 10.

Electrode Slope Check (with ion meter)

(check electrodes each day)

1. Prepare standard sodium solutions with concentrations that vary by tenfold. Use either the 0.1M Na^+ or the 1000 ppm Na^+ standard stock solutions. Use the serial dilution method for this preparation.
2. Add 100 ml of the lower value standard and 2 ml of ISA to a 150 ml beaker. Place the beaker on the magnetic stirrer and begin stirring at a constant rate. Lower the electrode tip into the solution. The meter must be in concentration mode.
3. Adjust the meter to the concentration of standard, and fix the value in the memory according to the meter instructions.
4. Rinse the electrode with distilled water and blot dry.
5. Add 100 ml of the higher value standard and 2 ml of ISA to a 150 ml beaker. Place the beaker on the magnetic stirrer and begin stirring at a constant rate. Lower the electrode tip into the solution.
6. Adjust the meter to the concentration of the standard and fix the value in the memory.
7. Read the electrode slope according to the meter instructions. Correct electrode operation is indicated by a slope of 90-100%. See "Troubleshooting Hints", Addendum 1, if the slope is not within this range.

4. Measurement

Measuring Hints

All samples and standards must be at the same temperature for precise measurement, preferably ambient temperature. A difference of 1°C in temperature will result in about a $\pm 2\%$ measurement error. Do not use electrodes above 70°C.

Constant—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 or asbestos sheet, between the stirrer and the beaker.

Always rinse the electrode with electrode rinse solution from a wash bottle. Blot dry with a clean, dry tissue

between readings to prevent solution carryover. NEVER use distilled water.

Store the electrode 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 measuring low level sodium, use a dilute sodium chloride storage solution, adjusting the pH by adding ISA, for a storage medium.

Use plastic labware for low level measurements.

All measurements must be made in basic solution. Adjust all samples and standards to a pH>9 with ISA.

For samples with high ionic strength, prepare standards with composition 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 units.

Table 1: Concentration Unit Conversion Factors

<u>ppm Na⁺</u>	<u>moles/liter Na⁺</u>
229.90	1.0×10^{-2}
22.99	1.0×10^{-3}
2.30	1.0×10^{-4}

5. Measurement Procedure

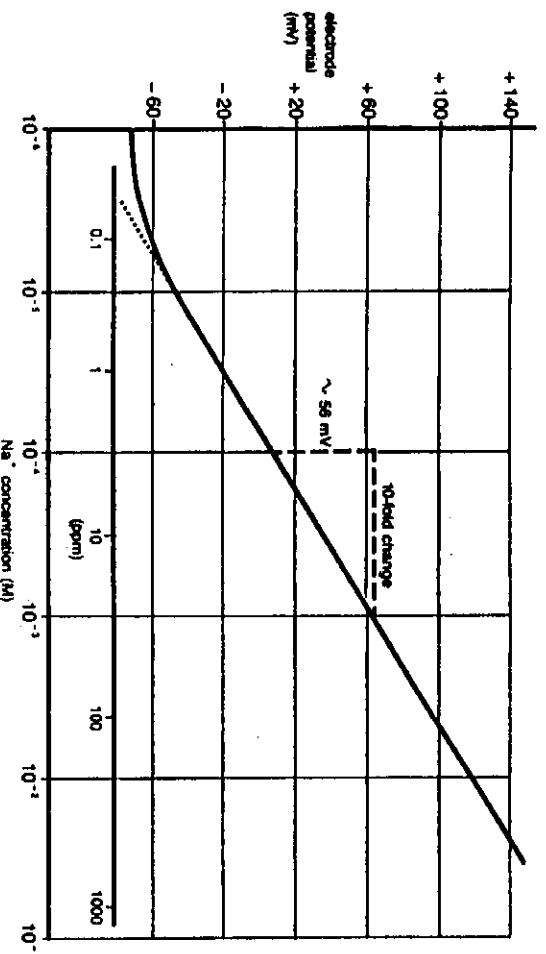
Direct Measurement

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 (using a pH/mV meter)

1. Prepare 10^{-2} , 10^{-3} , and 10^{-4} M or 100, 10, and 1 ppm standards by serial dilution of the 0.1M or 1000 ppm standard. Add 2 ml of ISA per 100 ml of standard.
2. Place the most dilute solution (10^{-4} M or 1 ppm) on the magnetic stirrer and begin stirring at a constant rate. After assuring that the meter is in the mV mode, lower the electrode tip into the solution. When the reading stabilizes, record the mV reading.
3. Place the midrange solution (10^{-3} M or 10 ppm) on the magnetic stirrer and begin stirring. After rinsing the electrode with distilled water and blotting dry, immerse the electrode tip in the solution. When the reading stabilizes, record the mV reading.
4. Place the most concentrated solution (10^{-2} M or 100 ppm) on the magnetic stirrer and begin stirring. After rinsing the electrode with distilled water and blotting dry, immerse the electrode tip in the solution. When the reading stabilizes, record the mV reading.
5. Using the semi-logarithmic graph paper, plot the mV reading (linear axis) against the concentration (log axis). A typical calibration curve can be found in Figure 1, next page.

Figure 1: Typical sodium electrode calibration curve



A calibration curve is constructed on semi-logarithmic graph paper when using a pH/mV meter in the millivolt mode. The measured electrode potential in mV (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 are for the linear portion of the curve. The low level procedures are for the non-linear portion of the curve.

Extrapolate the curve down to about 5.0×10^{-5} M or 1 ppm. For measurements below this level, follow the instructions for low-level measurement.

6. Add 100 ml of your sample and 2 ml of ISA to a clean dry 150 ml beaker. Place the beaker on the magnetic stirrer and begin stirring. After rinsing the electrode tip with sodium rinse solution, place the electrode tip in the solution. When the reading stabilizes, record the mV reading. Determine the concentration directly from the calibration curve.

7. Check the calibration every two hours. Assuming no change in ambient temperature, place the electrode tip in the mid-range standard. After the reading stabilizes, compare it to the original reading recorded in Step 3 above. If the reading differs by more than 0.5 mV or the ambient temperature changes, repeat Steps 2-5 above. Prepare a new calibration curve daily.

Direct Measurement of Sodium (using an ion meter)

1. By serial dilution of the 0.1M or 1000 ppm sodium standard, prepare two sodium standards whose concentration is near the expected sample concentration. Measure out 100 ml of each standard into individual 150 ml beakers and add 2 ml of ISA to each.
2. Place the more dilute solution on the magnetic stirrer and begin stirring at a constant rate. Make sure the meter is in the concentration mode.
3. Lower the electrode tip into the solution.
4. Adjust the meter to the concentration of the sodium standard. After the reading stabilizes, fix the value in the memory according to the meter instructions.
5. Rinse the electrode tip with distilled water and blot dry.
6. Place the more concentrated solution on the magnetic stirrer and begin stirring at a constant rate.
7. Lower the electrode tip into the solution.
8. Adjust the meter to the concentration of the sodium standard. After the reading stabilizes, fix the value in the memory according to the meter instructions.
9. For low level measurements, place the rinsed, dried electrode into a solution containing 100 ml of distilled water and 2 ml of ISA. After the reading stabilizes, fix the blank value in the meter according to the meter instructions.
10. Pour 100 ml of the sample and 2 ml of ISA into a 150 ml beaker. Set it on the magnetic stirrer, and begin stirring.

11. Immerse the electrode tip in the solution and wait for the reading to stabilize. Read the concentration directly from the meter display.
12. Recalibrate the electrode every 1-2 hours. Simply repeat Steps 2-8 (2-9) above.

Low Level Sodium Determination (using a standard pH/mV meter)

We recommend this procedure for solutions with ionic strength less than $1.0 \times 10^{-2}M$ and a sodium concentration less than $1 \times 10^{-3}M$ 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 labware for low sodium measurements.

1. Using 20 ml of standard ISA, dilute to 100 ml with distilled water.
2. If using a glass double junction electrode, dilute the reference filling solution by adding 20 ml of the filling solution to 80 ml of distilled water. Refill the reference chamber with this new diluted solution.
3. Dilute 1 ml of the $0.1M$ 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. Prepare fresh standards daily.
4. Add 100 ml of distilled water and 1 ml of low level ISA to a 150 ml plastic beaker. Add NH_4OH , if necessary, to adjust the pH above 9. Place the beaker on the magnetic stirrer and begin stirring at a constant rate.
5. Place the electrode tip in the solution. Make sure the meter is in the mV mode.
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 stabilizes, record the mV reading after each addition.

Table 2: Stepwise Calibration for Low Level Sodium Measurements

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

Pipet A = 1 ml graduated pipet Pipet B = 2 ml pipet

Solution = additions of $1.0 \times 10^{-3}M$ or 100 ppm standard to 100 ml of distilled water and 1 ml of low level ISA.

8. On semi-logarithmic graph-paper, plot the millivolt reading (linear axis) against the concentration (log axis) as in Figure 1, page 5.
9. Rinse the electrode with electrode rinse solution and blot dry.
10. Measure out 100 ml of the sample into a 150 ml plastic beaker, add 1 ml of low level ISA, and place the beaker on the magnetic stirrer. Begin stirring. Adjust the pH, if necessary, to above 9. Lower the electrode tip into the solution. After the reading stabilizes, record the mV reading 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.

Low Level Sodium Determination (using an ion meter)

Follow the procedure given for normal sodium determinations using an ion meter and the blank correction procedure. Use plastic labware for low level sodium measurement.

6. Electrode Characteristics

Reproducibility

Electrode measurements reproducible to $\pm 2\%$ 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 (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 indicate the presence of high interference from the ions listed. To restore proper response soak the electrodes in electrode storage solution when this happens. See Measuring Hints, page 3.

Table 3: Levels of Interfering Ions Resulting in a 10% Error at Specified Levels of Sodium.

<u>Interference</u>	<u>1.0 x 10⁻⁴M</u>	<u>1.0 x 10⁻³M</u>	<u>1.0 x 10⁻²M</u>
Li ⁺	5 x 10 ⁻⁴ M	5 x 10 ⁻³ M	5 x 10 ⁻² M
K ⁺	1 x 10 ⁻² M	1 x 10 ⁻¹ M	1M
Rb ⁺	3 x 10 ⁻¹ M	3M	—
NH ₄ ⁺	3 x 10 ⁻¹ M	3M	—
Ag ⁺	3 x 10 ⁻⁹ M	3 x 10 ⁻⁸ M	3 x 10 ⁻⁷ M
Tl ⁺	5 x 10 ⁻² M	5 x 10 ⁻¹ M	—
<u>Interference</u>	<u>1 ppm</u>	<u>10ppm</u>	<u>100ppm</u>
Li ⁺	1.5 ppm	15 ppm	150 ppm
K ⁺	17 ppm	170 ppm	1700 ppm
Rb ⁺	1.1 x 10 ⁴ ppm	1.1 x 10 ⁵ ppm	—
NH ₄ ⁺	1.8 x 10 ³ ppm	1.8 x 10 ⁴ ppm	—
Ag ⁺	.0001 ppm	.001 ppm	.01 ppm
Tl ⁺	4.5 x 10 ³ ppm	4.5 x 10 ⁴ ppm	—

Temperature Influences

Samples and standards must be at the same temperature, since electrode potentials are influenced by changes in temperature.

A 1°C difference in temperature results in a $\pm 2\%$ error at the 10⁻³M 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 sodium electrode, as indicated by the factor "S" in the Nernst equation, also varies with temperature. Table 4, page 8 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 must not be used at temperatures above 70°C, since damage to the membrane may result.

Table 4: Temperature vs Value for the Electrode Slope

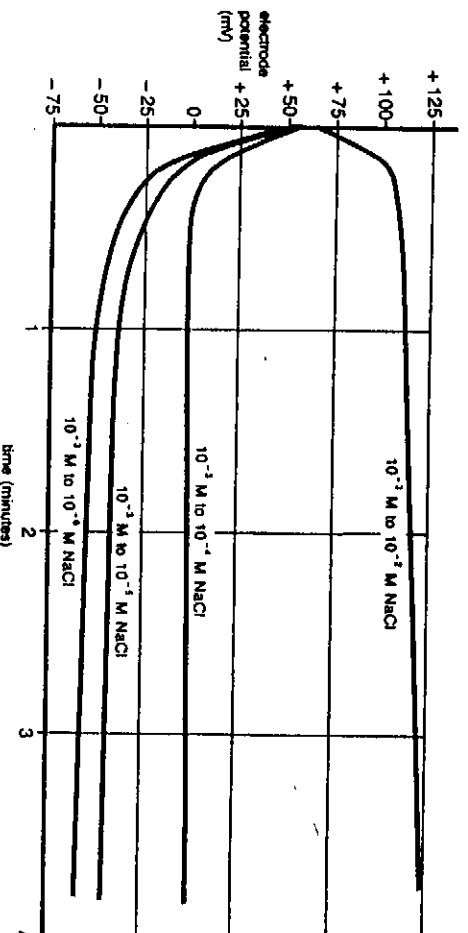
Temp (°C)	"S" (slope)	Temp (°C)	"S" (slope)
0	54.20	30	60.15
10	56.18	40	62.13
20	58.16	50	64.11
25	59.16		

Electrode Response

Plotting the electrode mV potential against the sodium concentration on semi-logarithmic paper results in a straight line with a slope of about 56 mV per decade. Refer to Figure 1, page 5.

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 2 below.

Figure 2: Typical electrode time response to step changes in NaCl



Detection Limit

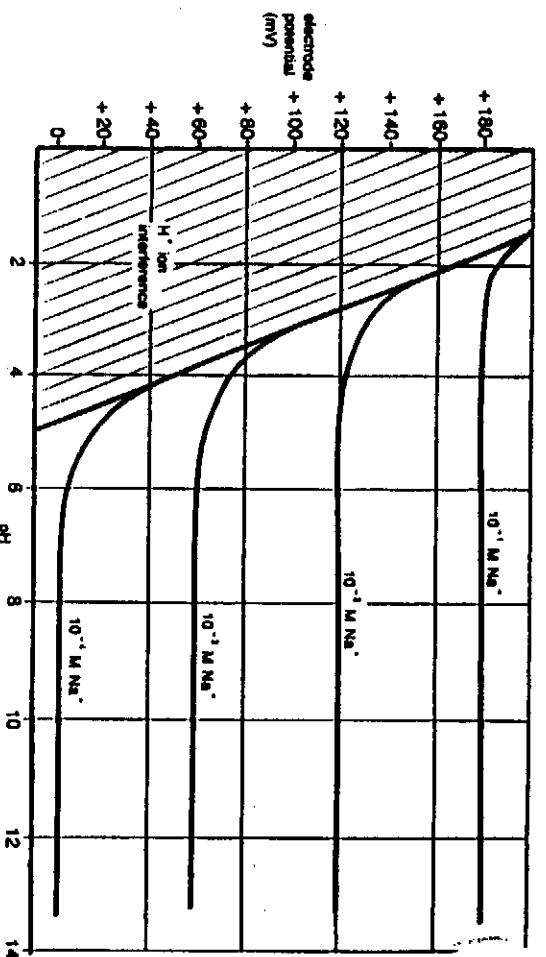
The upper limit of detection in pure sodium solutions is 1M. In the presence of other ions, the upper limit of detection is above $10^{-1}M$ sodium, but two factors influence this upper limit. Both the possibility of a liquid junction potential developing at the reference electrode and the salt extraction effect influence this upper limit. Some salts extract into the electrode membrane at high salt concentrations, causing deviation from the theoretical response. Either dilute samples between 1M 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 $10^{-6}M$ or 1 ppm, use plastic labware (and low level procedures) since a significant pickup of sodium may occur from glassware due to desorption 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 3 on the following page.

Figure 3: Electrode potential behavior vs. solution pH in pure NaCl solution at 25°C



The edge of the shaded area (the straight line) shown in Figure 3 indicates a minimum pH at which dilute sodium measurements can be made with less than 10% hydrogen ion interference.

The pH must 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 Storage

The Cole-Parmer® Sodium Electrodes must 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 the protective cap shipped with the electrode. The reference portion of the combination electrode should be drained of filling solution and the rubber insert placed over the filling hole.

Electrode Life

The sodium electrode lasts six months in normal laboratory use. On-line measurements might shorten operational lifetime to several months. In time, the response time increases and the calibration slope decreases to the point calibration is difficult and electrode replacement is required.

7. Electrode Theory

Electrode Operation

The Cole-Parmer® sodium electrodes have an epoxy or glass body and a sensing membrane. This sensing membrane has a liquid internal filling solution in contact with a gelled organophilic membrane containing a sodium selective ion exchanger.

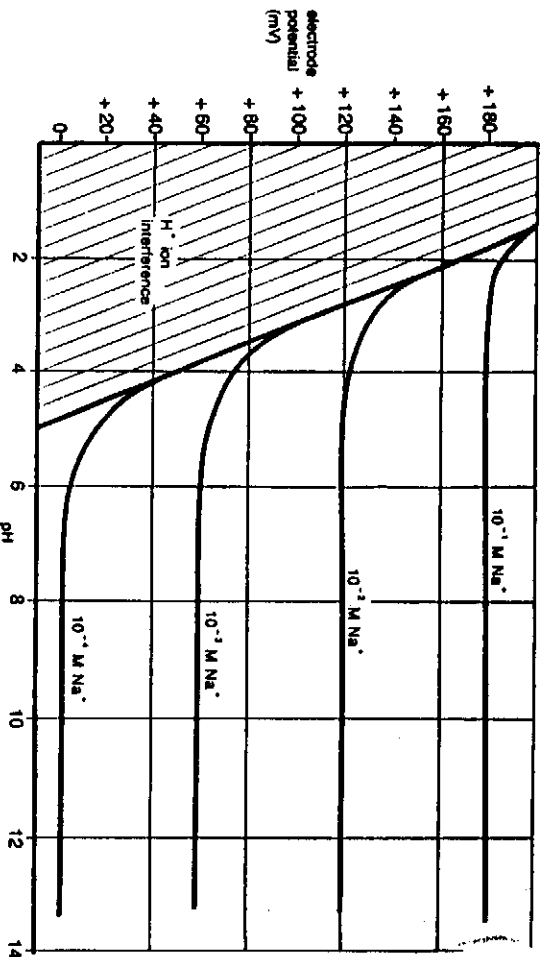
An electrode potential develops across the membrane when the membrane is in contact with a sodium solution. Measurement of this potential against a constant reference potential with a digital pH/mV meter or with a specific ion meter depends on the level of free sodium ion in solution. The level of sodium ions, corresponding to the measured potential, is described by the Nernst equation:

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

where:

E = measured electrode potential

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

where:

E = measured electrode potential

E_0 = reference potential (a constant)

S = electrode slope (~ 56 mV/decade)

X = level of sodium ions in solution

The activity, X , represents the effective concentration of the ions in solution. Total sodium concentration, C_t , includes free sodium ions, C_f , plus bound or complexed sodium ions, C_b . Since the sodium electrodes only respond to free ion, the free ion concentration is:

$$C_f = C_t - C_b$$

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

$$X = C_f$$

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

$$I = 1/2 C_x Z_x^2$$

where:

C_x = concentration of ion X

Z_x = charge of ion X

= 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 and constant value, add ionic strength adjuster (ISA) to samples and standards. The recommended ISA for sodium is ammonium chloride/Ammonium hydroxide, (NH_4Cl/NH_4OH). Other solutions may be used as long as the ions do not interfere with the electrode response to sodium ions.

The reference electrode must also be considered. When two solutions of different composition are brought into contact with one another, liquid junction potentials arise. Millivolt potentials occur from the interdiffusion of ions into the two solutions. Electrode charge is carried unequally across the solution boundary resulting in a potential difference between the two solutions, since ions diffuse at different rates. When measuring, remember that this potential must be the same when the reference is in both the standardizing solution and the sample solution. Otherwise, the change in liquid junction potential will appear as an error in the measured electrode potential.

The composition of the liquid junction filling solution in the reference electrode is most important. The speed with which the positive and negative ions in the filling solution diffuse into the sample will be as nearly equal as possible, that is, the filling solution will be equitransferent. No junction potential results if the rates at which positive and negative charges are carried into the sample are equal.

8. Troubleshooting Guide

Troubleshooting lets you isolate a problem by checking each of the system components: meter, plasticware, electrode, standards & reagents, sample, and the technique.

Meter

Follow the checkout procedure in the instrument instruction manual.

Plasticware

Clean plasticware is essential for good measurement. Be sure to wash the plasticware well with a mild detergent and rinse very well with distilled or deionized water. Clean plasticware will drain without leaving water droplets behind.

Electrode

Use the procedure found in "Electrode Slope Check", page 3.

1. Be sure to use distilled or deionized water when following this procedure.
2. If the electrode fails to respond as expected, see "Measuring Hints," page 3, and "Electrode Response," page 8. Repeat the slope check.
3. If the electrode still fails to respond as expected, try another sodium ion electrode that you know is in good working order.

4. If the problem persists, the reagent may be of poor quality, interferences may be in the sample, or the technique may be faulty. See "Standards & Reagents", "Sample", and "Technique" below.

5. If the electrode in use is suspect, or if another electrode is not available for test purposes, 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 with the proper ISA.
- Measure correctly and accurately.
- Review "Troubleshooting Hints", Addendum 1.

Standards & Reagents

Check the standard and reagent solutions if problems arise with a measuring procedure that worked for you before. 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 affect the response or physically damage the sensing electrode if the electrode 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" and "Sample Requirements," page 4, and "Interferences," page 7.

Technique

Be sure that you have not exceeded the electrode limit of detection.

Be sure that you clearly understand the analysis method and followed good laboratory practice.

Refer to the instruction manual again. Reread "General Preparation", page 3, and "Electrode Characteristics", page 7.

If trouble still persists, call Cole-Parmer at 1-800-323-4340 and ask for our Applications Specialists.

9. Replacement Electrodes and Solutions

Cat. No.	Description
MN-27502-42	Cole-Parmer® Sodium combination epoxy body electrode
MN-27502-43	Cole-Parmer® Sodium combination glass body electrode
MN-27503-33	Sodium Standard, 0.1M NaCl, 475 ml
MN-27503-34	Sodium Standard, 1000 ppm Na, 475 ml
MN-27503-82	Electrode filling solution for MN-27502-43, 0.1M NH_4Cl , 60 ml
MN-27503-76	Electrode filling solution for MN-27502-42, 0.1M NH_4Cl (saturated with Ag^+), 60 ml

Addendum 1: Troubleshooting Hints

Symptom	Possible Causes	Next Step
Out of Range Reading	defective meter	perform meter checkout (see meter instruction manual)
	electrode not plugged in properly	unplug electrode and reset
	reference electrode not filled	be sure reference electrode is filled
	air bubbles on membrane	remove bubble by redipping electrode
	electrode not in solution	put electrode in solution
"Incorrect Answer" (but calibration curve is good)	incorrect scaling of semi-log paper	plot millivolts 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 number correctly
	incorrect standards	prepare fresh standards
	wrong units used	apply correct conversion factor: $10^{-3}\text{M} = 23.0 \text{ ppm as Na}^{+1}$
	sample carryover	rinse electrodes thoroughly between samples
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 sodium standard
	incorrect reference filling solution	use recommended filling solution
	pH too low	adjust pH
	ISA not used	used recommend ISA
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
	defective electrode	check electrode operation
	electrode exposed to interferences	soak electrode in sodium standard
Noisy or Unstable Readings (readings continuously or randomly changing)	air bubble on membrane	remove bubble by redipping probe
	defective meter	perform meter checkout
	air bubble on membrane	remove bubble by redipping probe
	defective electrode	replace electrode
	electrode exposed to interferences	soak electrode in sodium standard
	meter or stirrer not grounded	ground meter or stirrer