

**INSTRUCTION MANUAL
model 701A
digital pH/mV meter**

2/86

ORION RESEARCH

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repair/service

For information on repair or replacement of this instrument, contact Orion Research toll-free. Ask for Customer Service.

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introduction

The Model 701A digital pH/mV meter is the ideal meter for all research and precision measurements with pH and chemical sensing electrodes. In both the absolute and relative mV modes, the meter covers a range of ± 1999.9 mV with ± 0.1 mV precision. The relative mV scale has a calibration potential of ± 200 mV. For pH measurements the meter offers a 0.01 pH scale with ± 0.01 pH relative accuracy and a 0.001 pH scale with ± 0.001 pH relative accuracy.

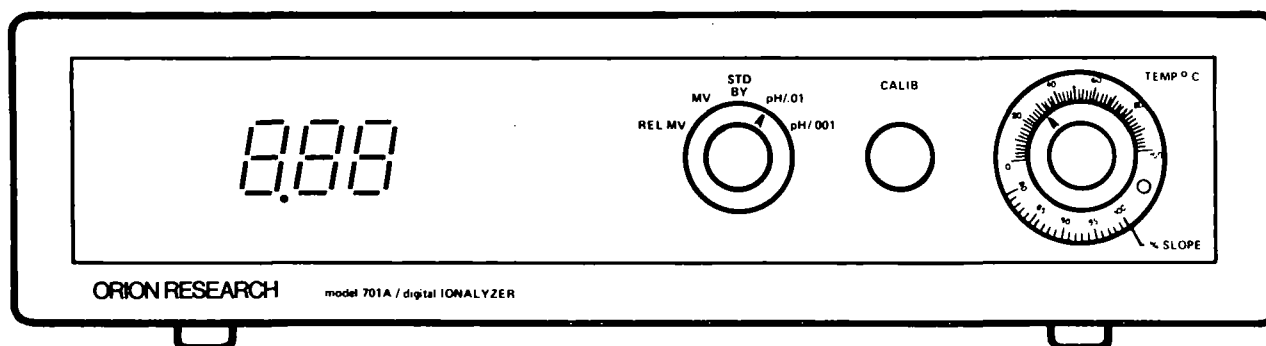
The 701A has a bright, long lasting LED display with automatic sign indication that eliminates interpolation and reading errors. It has an analog recorder output with span control and a parallel BCD digital output which permits the 701A to be used with compatible digital printers. A $10\mu\text{A}$ current is available for Karl Fischer titrations. Circuitry in the 701A is completely solid state, and the meter features high input impedance along with extremely low drift.

Operation of this versatile research tool is simple. We suggest that you read the entire instruction manual before attempting operation. This will familiarize you with the meter's controls and outputs, as well as give you an idea of the meter's potential uses.

The Model 701A is approved by the Canadian Standards Association (CSA).

instrument description

front panel



DISPLAY: The 701A automatically displays numerical data in bright, seven-segment LED numerals, with polarity sign and decimal point. Out-of-range data are indicated by blanked-out numerals with a + sign for over-range data and a - sign for under-range data. Standby operation is shown by a single decimal point in the middle of the display.

FUNCTION SWITCH: The function switch is used to select one of five operating modes.

STDBY: Indicated by decimal point only. Used instead of an "off" position to eliminate temperature fluctuations, to keep the instrument ready for use, and to increase component life.

pH/.01: for pH measurements precise to 0.01 pH units between pH 0.00 and pH 13.99. Blanks the third decimal place.

pH/.001: for pH measurements precise to 0.001 pH units between pH 0.000 and pH 13.999.

MV: for electrode potential measurements in mV precise to 0.1 mV between -1999.9 and + 1999.9 mV.

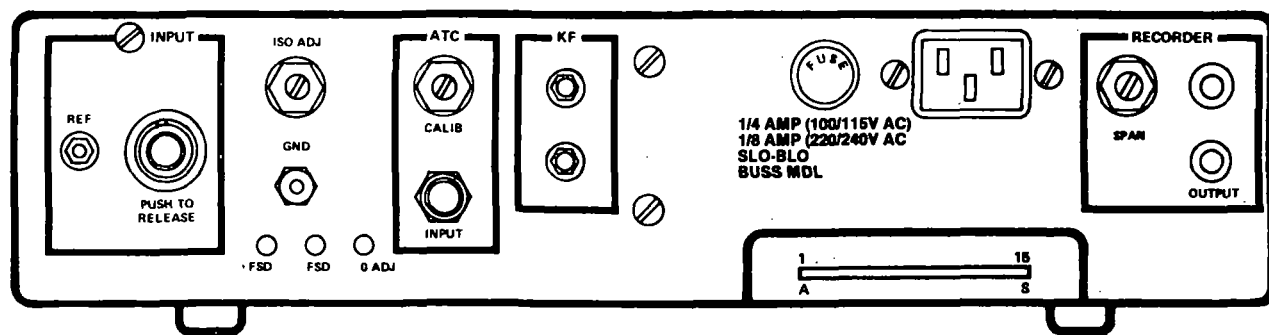
REL MV: for electrode potential measurements in mV precise to 0.1 mV between -1999.9 and + 1999.9 mV, adjustable with calibration control.

CALIB: calibration control adjusts pH and relative mV readings when calibrating the instrument-electrode system with standards of known activity, concentration, or pH. The control has a fine and coarse vernier adjustment, and is a ten-turn potentiometer with a nominal calibration range of ± 200 mV or ± 3.2 pH units. The calibration control has no effect on the absolute mV mode.

TEMP °C: black temperature compensator knob on a clear plastic dial which adjusts electrode slope in the pH modes when calibrating or changing temperature. The temperature scale is marked from 0°C to 100°C in 2°C divisions.

% SLOPE: clear plastic slope indicator dial shows the % of theoretical electrode slope. The slope scale is marked from 80% to 100% in 1% divisions. The dial has no input to meter function.

rear panel



REF: reference electrode jack. Accepts standard pin-tip connectors.

INPUT: sensing electrode jack. Accepts pH, specific ion, and redox electrodes with U.S. standard connectors.

ISO ADJ: isopotential point adjustment. Allows any buffer from pH 6 to 8 to be used with maximum accuracy in the two-buffer calibration procedure. See page 5.

GND: earth-ground jack for other system case grounds; e.g., magnetic stirrers. Jack accepts standard pin-tip connectors.

ATC INPUT: automatic temperature compensator jack. Accepts ORION automatic temperature compensator with phone plug. See page 14.

ATC CALIB: ATC adjustment. See page 14.

KF: polarizing current source ($-10\mu\text{A}$) for Karl Fischer titrations. Jacks accept standard pin-tip connectors. See page 8.

FUSE: accepts either 0.25 ampere SLO-BLO fuse - 100/115V AC; or 0.12 ampere SLO-BLO - 220/240V AC (Buss MDL).

LINE CORD: detachable line cord terminating in three-prong plug.

INTERFACE TAB: 8-4-2-1 binary coded decimal output with auxiliary information and input controls for printers, computers, magnetic data recorders, and other digital instruments (15 dual-pin positions). See page 13.

SPAN: adjusts recorder output voltage from 0 to 100 mV for full-scale reading. See page 13.

RECORDER: strip-chart recorder binding posts. Black post is low (ground) and red post is high input side of recorder.

+ FSD, -FSD: trim pots used only for servicing the meter. Any adjustment of these trim pots without a precision voltage source to standardize the input will disturb meter calibration.

0 ADJ: used to adjust mV display to 000.0 when a shorting strap is connected to REF and sensing inputs.

setup and checkout

setup

1. Unpack the 701A meter. Check that the package contains meter, line cord, swing arm electrode holder, shorting strap, and warranty card.
2. Check that the specifications label on the rear panel shows the correct line voltage. The 701A operates at 50 or 60 Hz without modification and is supplied to operate at 100V, 115V, 220V, or 240V as required. Meters supplied to operate at one of these voltages can be modified to operate at any other. Contact ORION for more information.
3. Connect the power cord of the 701A to a suitable power source. If your power source is not grounded, ground the meter chassis by connecting the green wire on a two-prong adapter plug to a water supply pipe or other suitable ground. The GND jack on the rear of the meter permits grounding of auxiliary instruments.
4. Outside North America a gray line cord is supplied with a molded mains plug. If this plug does not fit the available socket, replace it matching the **brown** wire to **live**, and **blue** wire to **neutral**, and the **green-and-yellow** wire to a suitable earth ground.

checkout

1. Allow meter to warm up for at least thirty minutes.
2. Connect the shorting strap (Cat. No. 040030) between the input jack and reference jack, and turn the function switch to STDBY.
3. With the function switch on STDBY, a decimal point only should be displayed.
4. Turn function switch to REL MV and verify display of polarity sign and four digits.
5. Using the calibration control, confirm that the display is adjustable from about -200 mV to + 200 mV. Adjust the calibration control for a display of 000.0. (Note: Remember this is a ten-turn potentiometer with a fine and coarse vernier adjustment.)
6. Turn the function switch to pH/.001.
7. Check display. It should read the isopotential point. (See page 5, **two-buffer standardization**, step 2.) Verify that slowly turning the temperature compensator knob has little or no effect upon the reading.
8. Turn the function switch to MV. The display should be 000.0 ± 0.1 . If not, adjust with the 0 ADJ on the rear panel.
9. Turn the function switch to pH/.001. Set the slope indicator dial to 100% and turn the temperature compensator knob until the white arrow points to 29°C. At this temperature a change of one pH unit corresponds to a 60 mV change in potential.
10. Turn the calibration control until a reading is obtained that is 0.50 pH units less than the isopotential point.
11. Set the function switch to REL MV and verify a display of 30.0 ± 0.3 mV.

If the meter does not checkout in any of the above steps, repeat the step. If the second attempt fails, see **warranty and service information**, on page 15.

pH measurements

general technique

1. To eliminate warm-up time and increase component life, always leave the meter in the STDBY mode rather than disconnected from line power. If the meter has been disconnected, allow a half-hour warm-up period before use.
2. Plug the pH and reference electrode connectors securely into the input and reference jacks on the rear panel of the 701A. Check that the reference electrode filling solution level is at least 1 inch (3 cm) above the solution being measured.
3. Allow all samples and buffers to reach the same temperature before attempting a measurement (unless an automatic temperature compensator is used).
4. Stir both buffer and sample solution with a magnetic stirrer while a measurement is being made. Some magnetic stirrers generate enough heat to increase the temperature of the solution. To avoid this, place a piece of thermal insulating material such as cork or styrofoam between the stirrer and beaker.
5. Rinse electrodes with distilled water between measurements.

single-buffer standardization

(Where maximum precision is not required.)

1. Place electrodes in a buffer solution with a pH value within 1.5 pH units of the expected value of the sample.
2. Turn the function switch to the pH/01 position. Set the slope indicator dial to 100%, and turn the temperature compensator knob to the temperature of the buffer.
3. Allow reading to stabilize and then adjust the calibration control so that the pH value of the buffer is displayed. Check the buffer package for the correct pH value at the buffer temperature.
4. Remove the electrodes from the buffer solution and rinse.
5. Place the electrodes in the unknown sample. Allow readings to stabilize.
6. Read the pH measurement directly from the display. When pH measurements are being made continuously, electrodes should be restandardized every 2 hours as a check on possible electrode drift caused by temperature changes and/or other factors. To restandardize, repeat steps 1 through 3 above.

two-buffer standardization

1. Select two buffers whose pH values bracket the expected sample pH, with one buffer between pH 6 and pH 8. Check the label on the buffer packet or bottle for the exact pH value at the solution temperature.
2. Set the isopotential point to the pH of the buffer between pH 6 and 8. To change the isopotential point from the factory setting of 7.000, connect the shorting strap between the input and reference jacks. Turn the function switch to REL MV and set the reading to 000.0 with the calibration control. Turn the function switch to pH/01. Turn the ISO ADJ screw on the back of the meter until the desired isopotential point is displayed.
3. Remove the shorting strap. Attach the combination pH electrode or pH electrode and reference electrode connectors securely to the meter. Turn the function switch to pH/01. For precision pH measurements, switch to pH/001.

4. Place electrodes in the buffer whose pH is the isopotential point. When display is stable, turn the calibration control until the correct pH value is displayed.
5. Remove the electrodes from the isopotential buffer and rinse.
6. Place the electrodes in the second buffer solution.
7. When display is stable, turn the temperature compensator until the pH value of the second buffer is displayed. Turn the slope indicator dial until the temperature compensator arrow points to the buffer temperature. Read the percent of the theoretical Nernst slope at the "% slope" index line. *If the % Nernstian slope is less than 90%, repeat the standardization with fresh buffers. If the % slope is again less than 90%, see troubleshooting, page 15.*
8. Remove electrodes, rinse, and place in the unknown sample.
9. Allow the reading to stabilize, and record the pH measurement directly from the display.

temperature compensation

If samples vary in temperature, or differ from the buffer temperature, manual or automatic temperature compensation is recommended.

manual temperature compensation

1. Calibrate meter according to the above instructions.
2. Measure temperature of the sample with a thermometer.
3. Turn the temperature compensator knob until arrow points to the correct temperature on the slope indicator dial.
4. Place electrodes in the sample and record the pH value when stable.

automatic temperature compensation (ATC)

See page 14 for ATC instructions.

recalibration

When pH measurements are being made continuously, electrodes should be restandardized every 2 hours as a check on possible electrode drift caused by temperature changes or other factors. If the ambient temperature has not changed, place the electrodes in the isopotential buffer and repeat step 4. If the ambient temperature has changed, repeat steps 2 through 6 above.

potentiometric measurements

general technique

1. To eliminate warm-up time and increase component life, always leave the meter in the STDBY mode rather than disconnected from line power. If the meter has been disconnected, allow a half-hour warm-up period before use.
2. Plug the chemical-sensing electrode and reference electrode connectors securely into the input and reference jacks on the rear panel of the 701A. Check that the reference electrode filling solution is at least 1 inch (3 cm) above the solution being measured.
3. Allow all samples and standards to reach the same temperature before attempting a measurement.
4. Stir both standards and samples with a magnetic stirrer while a measurement is being made. Some magnetic stirrers generate enough heat to increase the temperature of the solution. To avoid this, place a piece of thermal insulating material such as cork or styrofoam between the stirrer and beaker.
5. Rinse electrodes with distilled water between measurements.

direct measurement

Direct measurement is a simple procedure for measuring large numbers of samples. The method involves preparing a calibration curve from the electrode potential readings in solutions of known activities or concentrations. Unknown activities or concentrations are read from the calibration curve. Since curves can be made over many decades, a wide range of activity or concentration can be measured.

For direct measurement, an electrode for the species to be measured must exist, and stable standard solutions of the measured species must exist. The temperature of all standards and samples must be the same. If the background ionic strength is constant in all samples and standards, concentration rather than activity is measured.

1. Prepare three standards that differ in concentration by factors of 10. The standards should bracket the unknown sample concentration. Add the ionic strength adjustor, or pH adjustor, recommended by the electrode instruction manual. For greater accuracy, more standards may be prepared and measured.
2. Place electrodes in the mid-range standard.
3. Set the function switch to REL MV position. Wait for a stable reading. Adjust the calibration control until the meter reads 000.0. Since the offset potential in the REL MV mode is about ± 200 mV, it is impossible to zero the meter when the electrode potential is outside these limits; in these cases, simply turn the function switch to the MV position and record the electrode potentials to 0.1 mV.
4. Rinse electrodes and place in the most dilute standard. Wait for a stable reading and record.
5. Rinse electrodes and place in the most concentrated standard. Wait for a stable reading and record.
6. Using semilogarithmic graph paper, prepare a calibration curve by plotting the electrode potentials measured (mV readings) on the linear axis and the activity or concentration value of the standards on the logarithmic axis.
7. Rinse electrodes and place in the unknown sample. Wait for a stable reading and record.
8. Using the calibration curve, determine the concentration of the unknown.

recalibration

When specific ion determinations are being made continuously, electrodes should be recalibrated every 2 hours as a check on possible electrode drift caused by temperature change or other factors. If the ambient temperature has not changed and the reading was set to zero in step 3, recalibrate by repeating steps 2 and 3 above. If the ambient temperature has changed or if the meter could not be zeroed, repeat steps 2 through 6 above.

titrations

Precision potentiometric titrations can be performed with the 701A using either specific ion or redox electrodes. Titrations are more time consuming than direct electrode measurements, but results are more accurate. With careful technique, titrations accurate to $\pm 0.2\%$ of the total concentration of the ion being measured can be determined. Detailed instructions for making these titrations are given in each ORION electrode instruction manual. Directions for titrations with redox electrodes can be found in standard analytical texts. In general:

1. Prepare a titrant approximately 10 times the concentration of the estimated sample concentration.
2. Place the electrodes or electrode in the unknown solution. Set the function switch to the MV position.
3. Add increments of the titrant to the sample. Plot the volume of titrant added against the potential readings on the 701A.
4. Take as the endpoint the point of greatest slope and calculate the normality or molarity of the solution in the conventional manner.

polarized electrode titrations

A $10\mu\text{A}$ polarizing current is available for Karl Fischer or other titrations where polarized platinum electrodes are used.

1. With the function switch on MV, connect the shorting strap supplied between the sensing electrode input jack (INPUT) and one Karl Fischer input jack (KF).
2. Connect one platinum electrode to the rear panel reference jack (REF).
3. Connect the second platinum electrode to the white KF input jack.
4. Place the electrodes in the sample solution and perform the titration.

NOTE: Potentials measured are relative values. If it is necessary to know the absolute zero potential point, remove the electrodes from the solution and, with the polarizing current flowing and the function switch set to the MV position, touch the electrode tips together. The true zero point, which will be close to -200 mV , will display.

total concentration by addition and subtraction methods

Addition and subtraction methods are useful for measuring occasional samples as no calibration curve is required. The procedures are simple: A known amount of standard or reagent is added to a sample so that it increases the sample concentration (known addition) or decreases the sample concentration (known subtraction). From the change in potential before and after the addition, and the concentration of added standard or reagent, the sample concentration can be determined. Alternatively, a sample is added to a known standard or reagent so that it increases the standard concentration (analate addition) or decreases the reagent concentration (analate subtraction). From the change in potential before and after the addition of sample, and the concentration of the known standard or reagent, the sample concentration can be determined.

With addition and subtraction methods an accuracy of $\pm 2\%$ ($\pm 4\%$ for divalent electrodes) is possible. The electrode slope should be close to the value used to calculate the addition and subtraction tables in the **appendix**, complexing agents must either be absent or present in large excess, and the ionic strength of the solution should not change appreciably after the addition. Errors increase rapidly for potential changes less than 18 mV (9 mV for divalent electrodes). In order to choose a concentration of standard or reagent to maximize accuracy, sample concentration should be known in advance to within a factor of three.

known addition

Known addition is a useful method for measuring dilute samples. It measure the total concentration of an ion or dissolved gas, even in the presence of a large excess of complexing agents.

For known addition stable standard solutions of the species being measured and an electrode sensing the sample species are used.

1. Prepare a standard solution of the measured species about ten times as concentrated as the sample.
2. Place electrodes in 100 ml of the sample. Add the ionic strength adjustor, or pH adjustor, recommended by the electrode instruction manual. If complexing agents are present in the sample, they must be in large excess (50 to 100 times). Complexing agent may be added, if necessary. Stir with a magnetic stirrer throughout the measurement.
3. Turn the function switch of the meter to REL MV. Set the meter reading to 000.0 by turning the calibration control. If the meter cannot be set to 000.0, record the potential reading.
4. Add 10 ml of the standard solution.
5. Record the potential change, ΔE (magnitude only). If the meter could not be set to zero in step 3, determine the potential difference between the first and second readings. Turn to **appendix 1** and find the concentration ratio, Q , corresponding to ΔE in the column for a slope closest to your electrode slope. Most gas-sensing electrodes behave like monovalent electrodes.

Calculate sample concentration, C_s :

$$C_s = QC_r$$

where:

C_r is the standard concentration

If ΔE is lower than the values listed in the appendix, repeat the measurement with a more concentrated standard. If ΔE is too large for the appendix, repeat the measurement with a less concentrated standard. If your electrode slope is not listed in the appendix or other than a 10% volume change is used, see **appendix 5** for the appropriate equation for determining concentration.

analate addition

Analate (sample) addition is useful for viscous or very concentrated samples because the sample is diluted in the measurement. Small samples, if not too dilute, can be analyzed with analate addition. The method is not suitable for low-level samples. Total concentration is measured, even in the presence of complexing agents.

For analate addition an electrode sensing the sample species and stable standard solutions of the species are used.

1. Prepare a standard solution of the measured species about one tenth as concentrated as the sample.
2. Place electrodes in 100 ml of the standard. Add the ionic strength adjustor, or pH adjustor, recommended by the electrode instruction manual. If complexing agents are present in the sample, they must be added in large excess (50 to 100 times) to the standard solution. Stir with a magnetic stirrer throughout the measurement.
3. Turn the function switch to the REL MV position. If the meter cannot be set to 000.0, simply record the reading to ± 0.1 mV.

4. Add 10 ml of the sample solution.
5. Record the potential change, ΔE (magnitude only). If the meter could not be set to zero in step 3, determine the potential difference between the first and second reading. Turn to **appendix 2** and find the concentration ratio, Q , corresponding to ΔE in the column for a slope closest to your electrode slope. Most gas-sensing electrodes behave like monovalent electrodes.
6. Calculate sample concentration, C_s :

$$C_s = QC_r$$

where:

C_r is the standard concentration

If ΔE is lower than the values listed in the appendix, repeat the measurement with a less concentrated standard. If ΔE is too large for the appendix, repeat the measurement with a more concentrated standard. If your electrode slope is not listed in the appendix, or other than a 10% volume change is used, see **appendix 5** for the appropriate equation for determining concentration.

analate subtraction

Analate (sample) subtraction can be used to measure species for which no electrode exists. It is useful when sample size is small and for samples like sulfide for which a stable standard cannot be prepared. Viscous or very concentrated samples can be measured by analate subtraction because the sample is diluted. The method is not suited for very dilute samples. It is used to measure total concentration of an ion or dissolved gas, even in the presence of a large excess of complexing agents.

An electrode sensing a species that reacts with the sample is used for analate subtraction. Also, stable standards of the species reacting completely with the sample in a reaction of known stoichiometry are necessary.

1. Prepare a reagent solution that reacts with the measured species about $1/8n$ to $1/5n$ times as concentrated as the sample. The factor n is the stoichiometric ratio (see **table 1** below).

table 1

typical stoichiometric ratios (n)

sample	+	reagent	→	products	n
aS	+	bR	→	$S_a R_b$	a/b
S ⁼	+	Pb ⁺⁺	→	PbS	1
S ⁼	+	2Ag ⁺	→	Ag ₂ S	0.5
Al ⁺³	+	$\begin{cases} 3F^- \\ 2F^- \end{cases}$	→	AlF ₃ and AlF ₂ ⁺	0.37 (empirical)

2. Place electrodes in 100 ml of the reagent solution. Add the ionic strength adjustor, or pH adjustor, recommended by the electrode instruction manual. If complexing agents are present in the sample, add a large excess (50 to 100 times) to the reagent solution. Stir with a magnetic stirrer throughout the measurement.
3. Turn the function switch to REL MV. Set the meter reading to 000.0 by turning the calibration control. If the meter cannot be set to 000.0, simply record the reading to ± 0.1 mV.
4. Add 10 ml of the sample.

- Record the potential change, ΔE (magnitude only). If the meter could not be set to zero in step 3, determine the potential difference between the first and second readings. Turn to **appendix 3** and find the concentration ratio, Q , corresponding to ΔE in the column for the slope closest to your electrode slope. Most gas-sensing electrodes behave like monovalent electrodes.
- Calculate sample concentration, C_s (in moles per liter):

$$C_s = nQC_r$$

where:

C_r is the reagent concentration (in moles per liter) and n is the stoichiometric ratio (**table 1**).

If ΔE is lower than the values listed in the appendix, repeat the measurement with a less concentrated reagent. If ΔE is too large for the appendix, repeat the measurement with a more concentrated reagent.

Example: Suppose you have a sulfide sample about 1 to 3×10^{-3} M in concentration. Prepare a 5×10^{-4} silver nitrate standard and add 2 ml 4 M KNO_3 (the recommended ionic strength adjustor for silver measurements) to 100 ml. Place a silver-sensing electrode and reference electrode in the sample. Since the potential in this solution would be about 300 mV, the meter cannot be zeroed. Record the absolute mV reading. Add 10 ml sulfide sample. Suppose the potential difference is -17.0 mV at 25°C (59 mV slope); the value for Q from **appendix 3** is 4.33. The stoichiometric ratio (**table 1**) is 0.5. The sulfide sample concentration is:

$$\begin{aligned} C_s &= nQC_r \\ &= 0.5(4.33)(5 \times 10^{-4}) \\ &= 10.8 \times 10^{-4} = 1.08 \times 10^{-3} \text{ M} \end{aligned}$$

known subtraction

Known subtraction is a fast and simple version of titration, requiring only one addition of reagent to a sample. It is used to measure total concentration of an ion or dissolved gas, even in the presence of a large excess of complexing agents. It is useful for species for which stable standards do not exist (e.g., sulfide).

For known subtraction an electrode sensing the sample species is used. Stable standards of a species reacting completely with the sample in a reaction of known stoichiometry are necessary.

- Prepare a standard solution of a reagent that reacts with the measured species. Its concentration should be between $5/n$ and $8/n$ times the sample species concentration in moles per liter. The factor n is the stoichiometric ratio of moles of sample per mole of reagent (see **table 1**).
- Place electrodes in 100 ml of the sample. Add the ionic strength adjustor, or pH adjustor, recommended by the electrode instruction manual. If complexing agents are present in the sample, they must be in large excess (50 to 100 times). Complexing agent may be added, if necessary.
- Turn the function switch of the meter to REL MV. Set the meter reading to 000.0 by turning the calibration control. If the meter cannot be set to 000.0, simply record the reading to ± 0.1 mV.

4. Add 10 ml of the reagent.
5. Record the potential change, ΔE (magnitude only). If the meter could not be set to zero in step 3, determine the potential difference between the first and second readings. Turn to **appendix 4** and find the concentration ratio, Q , corresponding to ΔE in the column for the slope closest to your electrode slope. Most gas-sensing electrodes behave like monovalent electrodes.
6. Calculate sample concentration, C_s (in moles per liter):

$$C_s = nQC_r$$

where:

C_r is the reagent concentration (in moles per liter) and n is the stoichiometric ratio (**table 1**).

If ΔE is lower than the values listed in the appendix, repeat the measurement with a less concentrated reagent. If ΔE is too large for the appendix, repeat the measurement with a less concentrated reagent.

Example: Suppose you have a sample containing approximately 10^{-3} M sulfide. Place a silver/sulfide electrode in 100 ml of sample and set the meter reading to zero. Prepare a 10^{-4} M silver nitrate solution and add 10 ml to the sample. When the meter reading is steady, the potential change is 8.3 mV. At room temperature the sulfide electrode slope is 28.5 mV, so Q from **appendix 4** is 0.2303. From **table 1**, n is 0.5. The sulfide concentration is:

$$\begin{aligned} C_s &= nQC_r \\ &= 0.5 \times (0.2303) \times (10^{-4}) \\ &= 1.15 \times 10^{-3} \times 10^{-3} \text{ M sulfide} \end{aligned}$$

data recording

strip chart recording

The black and red rear panel binding posts provide an output for strip chart recording. For recorders with input impedance of at least 100 kilohms, the recorder output is adjustable to ± 100 mV for a full-scale display of ± 1999.9 mV. In the pH mode, output to the recorder is 0 mV at the isopotential point, and the gain is adjustable up to approximately 3 mV per pH unit change.

Lower impedance recorders may be used but full-scale output is reduced. To set up for strip chart recording:

1. Connect the lead from the high (input) side of the recorder to the red binding post and the lead from the low (ground) side to the black binding post.
2. Proceed according to the directions in the strip chart recorder instruction manual. If the instrument is a fixed-input type, use the rear panel recorder span control on the 701A to adjust the full-scale recorder display to conform to that of the 701A.

digital recording

A binary-coded decimal equivalent of the displayed measurement is available at the 15-pin printed circuit tab at the rear of the instrument. This output, with appropriate interfacing, may be used to activate digital instruments such as computers, controllers, printers, magnetic data recorders, and card or tape punches. Care should be taken when using the 701A with non-ORION equipment to avoid excessive loading. In some cases use of isolating circuitry would be recommended.

To design the necessary interface circuitry, a list of input-output data is provided below. Numbers are assigned to the connections from left to right, facing the rear panel. See table 2.

For all logic connections a voltage level of 1.7V or higher is "true," or 1, and a voltage level below 0.8V is "false," or 0. All logic is transistor-transistor logic. All signals are named for the condition which causes them to be a logic "1." Data outputs are 8-4-2-1 BCD.

table 2
input/output data for digital tab



pin outputs	function	pin outputs	function
A	- DIGITAL GND	1	- DIGITAL GND
B	- unused	2	- unused
C	- <u>BLANK</u>	3	- <u>unused</u>
D	- <u>LSD BLANK</u>	4	- <u>HOLD</u>
E	- <u>LAMP TEST</u>	5	- .2
F	- .1	6	- .4
H	- <u>MV DECIMAL POINT</u>	7	- .8
J	- 2	8	- 4
K	- 200	9	- 8
L	- 400	10	- 1
M	- 800	11	- <u>pH DECIMAL POINT</u>
N	- 100	12	- 20
P	- PLUS (+)	13	- 40
R	- DATA READY	14	- 80
S	- 1000	15	- 10

use with ORION accessories

use with ATC probe

The ATC probe bypasses the manual temperature correction control on the front panel with automatic compensation based on the sensed sample temperature. This compensation is accurate to $\pm .01$ pH units over the temperature range 0 to 100°C.

1. Set the isopotential point according to the instructions in step 1 of the **two-buffer standardization** on page 5.
2. Plug the ATC connector securely into the rear panel ATC input jack.
3. Place electrodes and ATC probe into isopotential buffer solution. Turn function switch to pH/.01 position.
4. Turn calibration control on front panel to obtain a display of the buffer value. Remember that buffer pH depends on temperature, (check buffer package for correct buffer values). Then turn function switch to STDBY.
5. Place electrodes and ATC probe in a buffer whose pH is about 3 pH units from the isopotential point. Turn function switch to pH/.01. Adjust rear panel ATC adjust to obtain a display of the second buffer value.
6. Place electrodes and ATC probe in sample and read the sample pH.

use with the model 605 manual electrode switch

Readings from up to six sensing electrodes or electrode pairs can be taken sequentially on the Model 701A when the electrode is used with the ORION Model 605 Manual Electrode Switch. Full instructions for the use of the switch are given in its instruction manual.

The following electrical connections are needed:

Connect the U.S. standard connector of the 605 cable to the sensing electrode (INPUT) jack of the 701A.

Connect the red pin-jack connector of the 605 cable to a reference electrode (REF) jack of the 701A.

Connect the gray pin-jack connector of the 605 cable to the grounding jack (GND) of the 701A.

Connect the black pin-jack connector to the negative or low recorder output jack (black).

NOTE: Five channels of the electrode switch are provided with calibration controls to adjust the individual electrode readings. These calibration controls are independent of each other but are all dependent on the 701A calibration potential; i.e., moving the calibration control on the front panel of the 701A will affect the readings obtained from all channels of the 605.

use with the model 951 digital printer

The ORION Model 951 digital printer can be interfaced with the 701A to provide hard copy of pH and mV values. To interface:

1. Disconnect 701A from power source.
2. Connect cable (Cat. No. 095112) to input P1 on rear of printer and BCD tab on rear of meter.
3. Connect 701A, then 951 to power source.

troubleshooting

Problems in making electrode measurements are due to either the sample chemistry, the electrodes, or the meter. If you are having measurement difficulties:

1. First attempt to prepare a calibration curve (see page 7) or perform a two-buffer standardization (see page 5). A successful curve or standardization would indicate that your sample chemistry composition is causing the difficulty. Inability to obtain a calibration curve would indicate the electrodes or meter is faulty.
2. Check electrode operation using the instructions in the electrode instruction manual. Make sure electrodes are securely plugged in and the function switch is set correctly. Check that the reference electrode is clean and has not become clogged.
3. Check meter operation using the instructions on page 4.
4. If there is no display on the 701A, check that the meter is plugged into a live outlet providing the required line voltage and that line voltage is not fluctuating more than $\pm 10\%$. Remove the fuse from the rear panel and check. If it has blown, replace with a 0.25-ampere (115V) or 0.12-ampere (220V) SLO-BLO fuse. Check meter operation using the instructions on page 4.
5. If the readings obtained during checkout are unstable, check that the instrument ground is secure. Also check that any accessory equipment is securely grounded to the meter. If grounding is not a problem, or if the readings obtained during checkout are drifting, return the instrument for repair.

warranty and service information

ORION warranty covers failures due to manufacturer's workmanship or material defect from the date of purchase by the user. User should return the warranty card to ORION and retain proof of purchase. Warranty is void if product has been abused, misused, or repairs attempted by unauthorized persons.

Warranties herein are for product sold/installed for use only in the United States and Canada. ORION products purchased for use in all other countries should consult their local in-country authorized ORION sales agent/distributor for product warranty information.

"No Lemon" Instrument Warranty

The Model 701A is covered by the ORION "No Lemon" warranty. If this instrument fails within twelve months from date of purchase for any reason other than abuse, the purchaser may elect to have it repaired or replaced at no charge. This warranty covers the original or replacement/repaired meter from date of original meter purchase; the warranty is not extended beyond the buyer's original warranty date.

A Return Authorization Number must be obtained from ORION Laboratory Products Customer Service before returning any product for in-warranty or out-of-warranty repair, replacement or credit.

appendix

appendix 1

Known addition table for an added volume one-tenth the sample volume. Slopes (in units of mV per decade) in the column header are for monovalent electrodes. For divalent electrodes, double the observed electrode slope before using the table.

ΔE		Q, concentration ratio				ΔE		Q, concentration ratio			
mono-valent	di-valent	(57.2)	(58.2)	(59.2)	(60.1)	mono-valent	di-valent	(57.2)	(58.2)	(59.2)	(60.1)
5.0	2.5	0.2894	0.2933	0.2972	0.3011	18.0	9.0	0.0786	0.0804	0.0822	0.0839
5.2	2.6	0.2806	0.2844	0.2883	0.2921	18.5	9.3	0.0759	0.0776	0.0793	0.0810
5.4	2.7	0.2722	0.2760	0.2798	0.2835	19.0	9.5	0.0733	0.0749	0.0766	0.0783
5.6	2.8	0.2642	0.2680	0.2717	0.2754	19.5	9.8	0.0708	0.0724	0.0740	0.0757
5.8	2.9	0.2567	0.2604	0.2640	0.2677	20.0	10.0	0.0684	0.0700	0.0716	0.0732
6.0	3.0	0.2495	0.2531	0.2567	0.2603	20.5	10.3	0.0661	0.0677	0.0693	0.0708
6.2	3.1	0.2426	0.2462	0.2498	0.2533	21.0	10.5	0.0640	0.0655	0.0670	0.0686
6.4	3.2	0.2361	0.2396	0.2431	0.2466	21.5	10.8	0.0619	0.0634	0.0649	0.0664
6.6	3.3	0.2298	0.2333	0.2368	0.2402	22.0	11.0	0.0599	0.0614	0.0629	0.0643
6.8	3.4	0.2239	0.2273	0.2307	0.2341	22.5	11.3	0.0580	0.0595	0.0609	0.0624
7.0	3.5	0.2181	0.2215	0.2249	0.2282	23.0	11.5	0.0562	0.0576	0.0590	0.0605
7.2	3.6	0.2127	0.2160	0.2193	0.2226	23.5	11.8	0.0545	0.0559	0.0573	0.0588
7.4	3.7	0.2074	0.2107	0.2140	0.2172	24.0	12.0	0.0528	0.0542	0.0555	0.0569
7.6	3.8	0.2024	0.2056	0.2088	0.2120	24.5	12.3	0.0512	0.0526	0.0539	0.0552
7.8	3.9	0.1975	0.2007	0.2039	0.2071	25.0	12.5	0.0497	0.0510	0.0523	0.0536
8.0	4.0	0.1929	0.1961	0.1992	0.2023	25.5	12.8	0.0482	0.0495	0.0508	0.0521
8.2	4.1	0.1884	0.1915	0.1946	0.1977	26.0	13.0	0.0468	0.0481	0.0493	0.0506
8.4	4.2	0.1841	0.1872	0.1902	0.1933	26.5	13.3	0.0455	0.0467	0.0479	0.0491
8.6	4.3	0.1800	0.1830	0.1860	0.1890	27.0	13.5	0.0442	0.0454	0.0466	0.0478
8.8	4.4	0.1760	0.1790	0.1820	0.1849	27.5	13.8	0.0429	0.0441	0.0453	0.0464
9.0	4.5	0.1722	0.1751	0.1780	0.1809	28.0	14.0	0.0417	0.0428	0.0440	0.0452
9.2	4.6	0.1685	0.1714	0.1742	0.1771	28.5	14.3	0.0405	0.0417	0.0428	0.0439
9.4	4.7	0.1649	0.1677	0.1706	0.1734	29.0	14.5	0.0394	0.0405	0.0416	0.0427
9.6	4.8	0.1614	0.1642	0.1671	0.1698	29.5	14.8	0.0383	0.0394	0.0405	0.0416
9.8	4.9	0.1581	0.1609	0.1636	0.1664	30.0	15.0	0.0373	0.0383	0.0394	0.0405
10.0	5.0	0.1548	0.1576	0.1603	0.1631	31.0	15.5	0.0353	0.0363	0.0373	0.0384
10.2	5.1	0.1517	0.1544	0.1571	0.1598	32.0	16.0	0.0334	0.0344	0.0354	0.0364
10.4	5.2	0.1487	0.1514	0.1540	0.1567	33.0	16.5	0.0317	0.0326	0.0336	0.0346
10.6	5.3	0.1458	0.1484	0.1510	0.1537	34.0	17.0	0.0300	0.0310	0.0319	0.0328
10.8	5.4	0.1429	0.1455	0.1481	0.1507	35.0	17.5	0.0285	0.0294	0.0303	0.0312
11.0	5.5	0.1402	0.1427	0.1453	0.1479	36.0	18.0	0.0271	0.0280	0.0288	0.0297
11.2	5.6	0.1375	0.1400	0.1426	0.1451	37.0	18.5	0.0257	0.0266	0.0274	0.0283
11.4	5.7	0.1349	0.1374	0.1399	0.1424	38.0	19.0	0.0245	0.0253	0.0261	0.0269
11.6	5.8	0.1324	0.1349	0.1373	0.1398	39.0	19.5	0.0233	0.0241	0.0249	0.0257
11.8	5.9	0.1299	0.1324	0.1348	0.1373	40.0	20.0	0.0222	0.0229	0.0237	0.0245
12.0	6.0	0.1276	0.1300	0.1324	0.1348	41.0	20.5	0.0211	0.0218	0.0226	0.0233
12.2	6.1	0.1253	0.1277	0.1301	0.1324	42.0	21.0	0.0201	0.0208	0.0215	0.0223
12.4	6.2	0.1230	0.1254	0.1278	0.1301	43.0	21.5	0.0192	0.0199	0.0205	0.0212
12.6	6.3	0.1208	0.1232	0.1255	0.1278	44.0	22.0	0.0183	0.0189	0.0196	0.0203
12.8	6.4	0.1187	0.1210	0.1233	0.1256	45.0	22.5	0.0174	0.0181	0.0187	0.0194
13.0	6.5	0.1167	0.1189	0.1212	0.1235	46.0	23.0	0.0166	0.0172	0.0179	0.0185
13.2	6.6	0.1146	0.1169	0.1192	0.1214	47.0	23.5	0.0159	0.0165	0.0171	0.0177
13.4	6.7	0.1127	0.1149	0.1172	0.1194	48.0	24.0	0.0151	0.0157	0.0163	0.0169
13.6	6.8	0.1108	0.1130	0.1152	0.1174	49.0	24.5	0.0145	0.0150	0.0156	0.0162
13.8	6.9	0.1089	0.1111	0.1133	0.1155	50.0	25.0	0.0138	0.0144	0.0149	0.0155
14.0	7.0	0.1071	0.1093	0.1114	0.1136	51.0	25.5	0.0132	0.0137	0.0143	0.0148
14.2	7.1	0.1053	0.1075	0.1096	0.1118	52.0	26.0	0.0126	0.0131	0.0136	0.0142
14.4	7.2	0.1036	0.1057	0.1079	0.1100	53.0	26.5	0.0120	0.0125	0.0131	0.0136
14.6	7.3	0.1019	0.1040	0.1061	0.1082	54.0	27.0	0.0115	0.0120	0.0125	0.0130
14.8	7.4	0.1003	0.1024	0.1045	0.1065	55.0	27.5	0.0110	0.0115	0.0120	0.0124
15.0	7.5	0.0987	0.1008	0.1028	0.1048	56.0	28.0	0.0105	0.0110	0.0115	0.0119
15.5	7.8	0.0949	0.0969	0.0989	0.1009	57.0	28.5	0.0101	0.0105	0.0110	0.0114
16.0	8.0	0.0913	0.0932	0.0951	0.0971	58.0	29.0	0.0096	0.0101	0.0105	0.0109
16.5	8.3	0.0878	0.0897	0.0916	0.0935	59.0	29.5	0.0092	0.0096	0.0101	0.0105
17.0	8.5	0.0846	0.0865	0.0883	0.0901	60.0	30.0	0.0088	0.0092	0.0096	0.0100
17.5	8.8	0.0815	0.0833	0.0852	0.0870						

Appendix 2

Sample addition table for an added volume one-tenth the standard solution volume. Slopes (in units of mV per decade) in the column headings are for monovalent electrodes. For divalent electrodes, double the observed electrode slope before using the table.

ΔE		Q, concentration ratio				ΔE		Q, concentration ratio			
mono-valent	di-valent	(57.2)	(58.2)	(59.2)	(60.1)	mono-valent	di-valent	(57.2)	(58.2)	(59.2)	(60.1)
5.0	2.5	3.4552	3.4091	3.3646	3.3217	18.0	9.0	12.719	12.440	12.173	11.918
5.2	2.6	3.5641	3.5157	3.4691	3.4241	18.5	9.3	13.181	12.888	12.609	12.341
5.4	2.7	3.6739	3.6232	3.5744	3.5274	19.0	9.5	13.653	13.346	13.053	12.773
5.6	2.8	3.7845	3.7315	3.6805	3.6314	19.5	9.8	14.135	13.813	13.506	13.214
5.8	2.9	3.8960	3.8407	3.7875	3.7362	20.0	10.0	14.626	14.289	13.969	13.663
6.0	3.0	4.0085	3.9508	3.8953	3.8418	20.5	10.3	15.127	14.775	14.440	14.120
6.2	3.1	4.1218	4.0618	4.0039	3.9483	21.0	10.5	15.638	15.271	14.920	14.586
6.4	3.2	4.2361	4.1736	4.1134	4.0555	21.5	10.8	16.160	15.776	15.410	15.062
6.6	3.3	4.3513	4.2863	4.2238	4.1636	22.0	11.0	16.692	16.292	15.910	15.546
6.8	3.4	4.4674	4.3999	4.3350	4.2725	22.5	11.3	17.236	16.817	16.419	16.040
7.0	3.5	4.5845	4.5144	4.4471	4.3822	23.0	11.5	17.790	17.354	16.939	16.544
7.2	3.6	4.7025	4.6299	4.5600	4.4928	23.5	11.8	18.355	17.901	17.469	17.057
7.4	3.7	4.8215	4.7462	4.6739	4.6043	24.0	12.0	18.933	18.459	18.009	17.580
7.6	3.8	4.9414	4.8635	4.7886	4.7166	24.5	12.3	19.521	19.028	18.559	18.113
7.8	3.9	5.0623	4.9817	4.9043	4.8297	25.0	12.5	20.122	19.609	19.121	18.657
8.0	4.0	5.1842	5.1009	5.0208	4.9438	25.5	12.8	20.735	20.201	19.694	19.211
8.2	4.1	5.3070	5.2209	5.1382	5.0587	26.0	13.0	21.361	20.805	20.277	19.776
8.4	4.2	5.4309	5.3420	5.2566	5.1745	26.5	13.3	21.999	21.421	20.873	20.351
8.6	4.3	5.5557	5.4640	5.3759	5.2911	27.0	13.5	22.650	22.050	21.480	20.938
8.8	4.4	5.6816	5.5870	5.4961	5.4087	27.5	13.8	23.315	22.691	22.099	21.536
9.0	4.5	5.8085	5.7110	5.6173	5.5272	28.0	14.0	23.993	23.344	22.730	22.146
9.2	4.6	5.9364	5.8359	5.7394	5.6466	28.5	14.3	24.684	24.011	23.373	22.768
9.4	4.7	6.0653	5.9618	5.8624	5.7669	29.0	14.5	25.390	24.692	24.029	23.401
9.6	4.8	6.1953	6.0888	5.9865	5.8881	29.5	14.8	26.111	25.386	24.699	24.047
9.8	4.9	6.3264	6.2167	6.1115	6.0103	30.0	15.0	26.846	26.093	25.381	24.705
10.0	5.0	6.4585	6.3457	6.2374	6.1334	31.0	15.5	28.361	27.551	26.786	26.060
10.2	5.1	6.5916	6.4757	6.3644	6.2575	32.0	16.0	29.938	29.069	28.247	27.468
10.4	5.2	6.7259	6.6067	6.4923	6.3825	33.0	16.5	31.580	30.647	29.765	28.931
10.6	5.3	6.8612	6.7388	6.6213	6.5085	34.0	17.0	33.290	32.289	31.344	30.451
10.8	5.4	6.9977	6.8719	6.7512	6.6354	35.0	17.5	35.070	33.998	32.986	32.030
11.0	5.5	7.1352	7.0061	6.8822	6.7633	36.0	18.0	36.923	35.775	34.693	33.671
11.2	5.6	7.2739	7.1413	7.0142	6.8922	37.0	18.5	38.852	37.625	36.468	35.376
11.4	5.7	7.4136	7.2777	7.1473	7.0221	38.0	19.0	40.861	39.549	38.313	37.148
11.6	5.8	7.5545	7.4151	7.2813	7.1530	39.0	19.5	42.952	41.551	40.232	38.989
11.8	5.9	7.6966	7.5536	7.4164	7.2849	40.0	20.0	45.129	43.633	42.227	40.901
12.0	6.0	7.8398	7.6932	7.5524	7.4178	41.0	20.5	47.396	45.800	44.301	42.889
12.2	6.1	7.9841	7.8339	7.6899	7.5517	42.0	21.0	49.756	48.055	46.457	44.953
12.4	6.2	8.1296	7.9757	7.8282	7.6867	43.0	21.5	52.213	50.400	48.699	47.099
12.6	6.3	8.2763	8.1187	7.9676	7.8227	44.0	22.0	54.771	52.841	51.030	49.328
12.8	6.4	8.4242	8.2627	8.1081	7.9597	45.0	22.5	57.434	55.379	53.453	51.645
13.0	6.5	8.5733	8.4080	8.2496	8.0978	46.0	23.0	60.207	58.021	55.973	54.051
13.2	6.6	8.7236	8.5544	8.3923	8.2370	47.0	23.5	63.094	60.769	58.593	56.552
13.4	6.7	8.8751	8.7019	8.5361	8.3772	48.0	24.0	66.099	63.628	61.317	59.151
13.6	6.8	9.0278	8.8507	8.6811	8.5185	49.0	24.5	69.228	66.603	64.149	61.850
13.8	6.9	9.1817	9.0006	8.8271	8.6609	50.0	25.0	72.486	69.698	67.093	64.656
14.0	7.0	9.3370	9.1517	8.9743	8.8044	51.0	25.5	75.877	72.918	70.155	67.570
14.2	7.1	9.4934	9.3040	9.1227	8.9490	52.0	26.0	79.408	76.268	73.338	70.599
14.4	7.2	9.6512	9.4575	9.2722	9.0947	53.0	26.5	83.084	79.753	76.647	73.746
14.6	7.3	9.8102	9.6123	9.4229	9.2415	54.0	27.0	86.912	83.379	80.088	77.015
14.8	7.4	9.9704	9.7682	9.5748	9.3895	55.0	27.5	90.897	87.152	83.665	80.412
15.0	7.5	10.132	9.9255	9.7278	9.5386	56.0	28.0	95.045	91.077	87.385	83.942
15.2	7.6	10.296	10.084	9.8786	9.6886	57.0	28.5	99.364	95.161	91.252	87.410
15.4	7.7	10.462	10.245	10.031	9.8395	58.0	29.0	103.86	99.409	95.273	91.421
15.6	7.8	10.630	10.408	10.184	9.9914	59.0	29.5	108.54	103.83	99.453	95.381
15.8	7.9	10.800	10.574	10.338	10.144	60.0	30.0	113.42	108.43	103.80	99.495

appendix 3

Sample subtraction table for an added volume one-tenth the reagent volume. Slopes (in units of mV per decade) in the column headings are for monovalent electrodes. For divalent electrodes, double the observed electrode slope before using the table

ΔE		Q, concentration ratio				ΔE		Q, concentration ratio			
mono-valent	di-valent	(57.2)	(58.2)	(59.2)	(60.1)	mono-valent	di-valent	(57.2)	(58.2)	(59.2)	(60.1)
5.0	2.5	1.0072	0.9763	0.9462	0.9171	18.0	9.0	4.6740	4.6077	4.5428	4.4793
5.2	2.6	1.0794	1.0475	1.0165	0.9864	18.5	9.3	4.7803	4.7135	4.6481	4.5841
5.4	2.7	1.1510	1.1181	1.0862	1.0552	19.0	9.5	4.8844	4.8171	4.7513	4.6868
5.6	2.8	1.2220	1.1882	1.1553	1.1234	19.5	9.8	4.9864	4.9187	4.8525	4.7876
5.8	2.9	1.2925	1.2577	1.2239	1.1912	20.0	10.0	5.0864	5.0184	4.9517	4.8864
6.0	3.0	1.3624	1.3267	1.2920	1.2584	20.5	10.3	5.1844	5.1161	5.0491	4.9834
6.2	3.1	1.4317	1.3951	1.3596	1.3251	21.0	10.5	5.2805	5.2118	5.1445	5.0786
6.4	3.2	1.5005	1.4630	1.4266	1.3913	21.5	10.8	5.3746	5.3057	5.2382	5.1719
6.6	3.3	1.5687	1.5304	1.4931	1.4570	22.0	11.0	5.4669	5.3978	5.3300	5.2635
6.8	3.4	1.6364	1.5972	1.5591	1.5222	22.5	11.3	5.5573	5.4880	5.4200	5.3533
7.0	3.5	1.7035	1.6635	1.6246	1.5869	23.0	11.5	5.6459	5.5765	5.5084	5.4415
7.2	3.6	1.7701	1.7293	1.6896	1.6511	23.5	11.8	5.7327	5.6632	5.5950	5.5279
7.4	3.7	1.8362	1.7945	1.7541	1.7148	24.0	12.0	5.8179	5.7483	5.6799	5.6128
7.6	3.8	1.9017	1.8593	1.8180	1.7780	24.5	12.3	5.9013	5.8316	5.7632	5.6960
7.8	3.9	1.9667	1.9235	1.8815	1.8407	25.0	12.5	5.9830	5.9134	5.8449	5.7776
8.0	4.0	2.0312	1.9872	1.9445	1.9030	25.5	12.8	6.0631	5.9935	5.9250	5.8577
8.2	4.1	2.0951	2.0504	2.0070	1.9648	26.0	13.0	6.1417	6.0721	6.0036	5.9363
8.4	4.2	2.1586	2.1132	2.0690	2.0261	26.5	13.3	6.2186	6.1491	6.0807	6.0134
8.6	4.3	2.2215	2.1754	2.1305	2.0869	27.0	13.5	6.2941	6.2246	6.1563	6.0890
8.8	4.4	2.2840	2.2371	2.1916	2.1473	27.5	13.8	6.3680	6.2986	6.2304	6.1632
9.0	4.5	2.3459	2.2984	2.2522	2.2072	28.0	14.0	6.4404	6.3712	6.3031	6.2359
9.2	4.6	2.4073	2.3591	2.3123	2.2667	28.5	14.3	6.5114	6.4424	6.3743	6.3073
9.4	4.7	2.4683	2.4194	2.3719	2.3257	29.0	14.5	6.5810	6.5121	6.4443	6.3781
9.6	4.8	2.5287	2.4792	2.4311	2.3843	29.5	14.8	6.6492	6.5805	6.5128	6.4489
9.8	4.9	2.5887	2.5386	2.4898	2.4424	30.0	15.0	6.7160	6.6476	6.5801	6.5197
10.0	5.0	2.6482	2.5974	2.5481	2.5001	31.0	15.5	6.8457	6.7778	6.7107	6.6445
10.2	5.1	2.7072	2.6559	2.6059	2.5573	32.0	16.0	6.9703	6.9029	6.8363	6.7706
10.4	5.2	2.7657	2.7138	2.6633	2.6141	33.0	16.5	7.0899	7.0232	6.9572	6.8919
10.6	5.3	2.8238	2.7713	2.7202	2.6704	34.0	17.0	7.2049	7.1388	7.0734	7.0087
10.8	5.4	2.8814	2.8283	2.7767	2.7264	35.0	17.5	7.3153	7.2499	7.1852	7.1211
11.0	5.5	2.9385	2.8849	2.8327	2.7819	36.0	18.0	7.4213	7.3567	7.2927	7.2293
11.2	5.6	2.9952	2.9411	2.8883	2.8369	37.0	18.5	7.5231	7.4593	7.3961	7.3334
11.4	5.7	3.0514	2.9967	2.9435	2.8916	38.0	19.0	7.6210	7.5580	7.4955	7.4336
11.6	5.8	3.1072	3.0520	2.9982	2.9458	39.0	19.5	7.7149	7.6528	7.5912	7.5300
11.8	5.9	3.1625	3.1068	3.0526	2.9997	40.0	20.0	7.8052	7.7440	7.6832	7.6229
12.0	6.0	3.2174	3.1612	3.1065	3.0531	41.0	20.5	7.8918	7.8316	7.7717	7.7122
12.2	6.1	3.2718	3.2152	3.1599	3.1061	42.0	21.0	7.9751	7.9158	7.8568	7.7981
12.4	6.2	3.3258	3.2687	3.2130	3.1587	43.0	21.5	8.0551	7.9967	7.9386	7.8809
12.6	6.3	3.3794	3.3218	3.2657	3.2109	44.0	22.0	8.1319	8.0745	8.0174	7.9605
12.8	6.4	3.4326	3.3745	3.3179	3.2627	45.0	22.5	8.2057	8.1493	8.0931	8.0371
13.0	6.5	3.4853	3.4268	3.3697	3.3141	46.0	23.0	8.2765	8.2211	8.1659	8.1109
13.2	6.6	3.5376	3.4786	3.4212	3.3651	47.0	23.5	8.3446	8.2902	8.2360	8.1819
13.4	6.7	3.5894	3.5301	3.4722	3.4158	48.0	24.0	8.4100	8.3566	8.3034	8.2502
13.6	6.8	3.6409	3.5811	3.5229	3.4660	49.0	24.5	8.4728	8.4204	8.3682	8.3160
13.8	6.9	3.6919	3.6318	3.5731	3.5159	50.0	25.0	8.5331	8.4818	8.4305	8.3792
14.0	7.0	3.7426	3.6820	3.6230	3.5653	51.0	25.5	8.5910	8.5407	8.4904	8.4401
14.2	7.1	3.7928	3.7319	3.6725	3.6144	52.0	26.0	8.6467	8.5974	8.5481	8.4987
14.4	7.2	3.8426	3.7813	3.7215	3.6632	53.0	26.5	8.7001	8.6519	8.6035	8.5552
14.6	7.3	3.8920	3.8304	3.7703	3.7115	54.0	27.0	8.7515	8.7042	8.6569	8.6094
14.8	7.4	3.9411	3.8791	3.8186	3.7595	55.0	27.5	8.8008	8.7545	8.7082	8.6617
15.0	7.5	3.9897	3.9274	3.8665	3.8071	56.0	28.0	8.8481	8.8029	8.7575	8.7120
15.5	7.8	4.1096	4.0465	3.9848	3.9246	57.0	28.5	8.8936	8.8494	8.8050	8.7604
16.0	8.0	4.2271	4.1632	4.1008	4.0398	58.0	29.0	8.9373	8.8941	8.8506	8.8070
16.5	8.3	4.3422	4.2777	4.2146	4.1529	59.0	29.5	8.9793	8.9370	8.8945	8.8517
17.0	8.5	4.4551	4.3899	4.3261	4.2638	60.0	30.0	9.0196	8.9783	8.9367	8.8949
17.5	8.8	4.5657	4.4999	4.4355	4.3726						

Appendix 4

Correction subtraction table for an added volume one-tenth the sample volume. Slopes (in units of mV per decade) in the column headings are for monovalent electrodes. For divalent electrodes, double the observed electrode slope before using the table.

ΔE		Q, concentration ratio				ΔE		Q, concentration ratio			
mono-valent	di-valent	(57.2)	(58.2)	(59.2)	(60.1)	mono-valent	di-valent	(57.2)	(58.2)	(59.2)	(60.1)
5.0	2.5	0.9928	1.0243	1.0569	1.0904	18.0	9.0	0.2140	0.2170	0.2201	0.2233
5.2	2.6	0.9265	0.9547	0.9838	1.0138	18.5	9.3	0.2092	0.2122	0.2152	0.2182
5.4	2.7	0.8688	0.8944	0.9207	0.9477	19.0	9.5	0.2047	0.2076	0.2105	0.2134
5.6	2.8	0.8183	0.8416	0.8656	0.8901	19.5	9.8	0.2006	0.2033	0.2061	0.2089
5.8	2.9	0.7737	0.7951	0.8171	0.8395	20.0	10.0	0.1966	0.1993	0.2020	0.2047
6.0	3.0	0.7340	0.7538	0.7740	0.7947	20.5	10.3	0.1929	0.1955	0.1981	0.2007
6.2	3.1	0.6985	0.7168	0.7355	0.7547	21.0	10.5	0.1894	0.1919	0.1944	0.1969
6.4	3.2	0.6665	0.6835	0.7010	0.7188	21.5	10.8	0.1861	0.1885	0.1909	0.1934
6.6	3.3	0.6375	0.6535	0.6697	0.6864	22.0	11.0	0.1829	0.1853	0.1876	0.1900
6.8	3.4	0.6111	0.6261	0.6414	0.6570	22.5	11.3	0.1800	0.1822	0.1845	0.1868
7.0	3.5	0.5870	0.6012	0.6155	0.6302	23.0	11.5	0.1771	0.1793	0.1816	0.1838
7.2	3.6	0.5650	0.5783	0.5919	0.6057	23.5	11.8	0.1744	0.1766	0.1787	0.1809
7.4	3.7	0.5446	0.5573	0.5701	0.5832	24.0	12.0	0.1719	0.1740	0.1761	0.1782
7.6	3.8	0.5259	0.5379	0.5501	0.5624	24.5	12.3	0.1695	0.1715	0.1735	0.1756
7.8	3.9	0.5085	0.5199	0.5315	0.5433	25.0	12.5	0.1671	0.1691	0.1711	0.1731
8.0	4.0	0.4923	0.5032	0.5143	0.5255	25.5	12.8	0.1649	0.1669	0.1688	0.1707
8.2	4.1	0.4773	0.4877	0.4983	0.5090	26.0	13.0	0.1628	0.1647	0.1666	0.1685
8.4	4.2	0.4633	0.4732	0.4833	0.4936	26.5	13.3	0.1608	0.1626	0.1645	0.1663
8.6	4.3	0.4502	0.4597	0.4694	0.4792	27.0	13.5	0.1589	0.1607	0.1624	0.1642
8.8	4.4	0.4378	0.4470	0.4563	0.4657	27.5	13.8	0.1570	0.1588	0.1605	0.1623
9.0	4.5	0.4263	0.4351	0.4440	0.4531	28.0	14.0	0.1553	0.1570	0.1587	0.1604
9.2	4.6	0.4154	0.4239	0.4325	0.4412	28.5	14.3	0.1536	0.1552	0.1569	0.1586
9.4	4.7	0.4052	0.4133	0.4216	0.4300	29.0	14.5	0.1520	0.1536	0.1552	0.1568
9.6	4.8	0.3955	0.4034	0.4113	0.4194	29.5	14.8	0.1504	0.1520	0.1536	0.1551
9.8	4.9	0.3863	0.3939	0.4016	0.4094	30.0	15.0	0.1489	0.1504	0.1520	0.1535
10.0	5.0	0.3776	0.3850	0.3925	0.4000	31.0	15.5	0.1461	0.1476	0.1490	0.1505
10.2	5.1	0.3694	0.3765	0.3838	0.3911	32.0	16.0	0.1435	0.1449	0.1463	0.1477
10.4	5.2	0.3616	0.3685	0.3755	0.3826	33.0	16.5	0.1411	0.1424	0.1437	0.1451
10.6	5.3	0.3541	0.3609	0.3676	0.3745	34.0	17.0	0.1388	0.1401	0.1414	0.1427
10.8	5.4	0.3471	0.3536	0.3602	0.3668	35.0	17.5	0.1367	0.1379	0.1392	0.1404
11.0	5.5	0.3403	0.3466	0.3530	0.3595	36.0	18.0	0.1348	0.1359	0.1371	0.1383
11.2	5.6	0.3339	0.3400	0.3462	0.3525	37.0	18.5	0.1329	0.1341	0.1352	0.1364
11.4	5.7	0.3277	0.3337	0.3397	0.3458	38.0	19.0	0.1312	0.1323	0.1334	0.1345
11.6	5.8	0.3218	0.3277	0.3335	0.3395	39.0	19.5	0.1296	0.1307	0.1317	0.1328
11.8	5.9	0.3162	0.3219	0.3276	0.3334	40.0	20.0	0.1281	0.1291	0.1302	0.1312
12.0	6.0	0.3108	0.3163	0.3219	0.3275	41.0	20.5	0.1267	0.1277	0.1287	0.1297
12.2	6.1	0.3056	0.3110	0.3165	0.3220	42.0	21.0	0.1254	0.1263	0.1273	0.1282
12.4	6.2	0.3007	0.3059	0.3112	0.3166	43.0	21.5	0.1242	0.1251	0.1260	0.1269
12.6	6.3	0.2959	0.3011	0.3062	0.3114	44.0	22.0	0.1230	0.1239	0.1247	0.1256
12.8	6.4	0.2913	0.2964	0.3014	0.3065	45.0	22.5	0.1219	0.1227	0.1236	0.1244
13.0	6.5	0.2869	0.2918	0.2968	0.3017	46.0	23.0	0.1208	0.1216	0.1225	0.1233
13.2	6.6	0.2827	0.2875	0.2923	0.2972	47.0	23.5	0.1198	0.1206	0.1214	0.1222
13.4	6.7	0.2786	0.2833	0.2880	0.2928	48.0	24.0	0.1189	0.1197	0.1204	0.1212
13.6	6.8	0.2747	0.2793	0.2839	0.2885	49.0	24.5	0.1180	0.1188	0.1195	0.1203
13.8	6.9	0.2709	0.2754	0.2799	0.2844	50.0	25.0	0.1172	0.1179	0.1186	0.1194
14.0	7.0	0.2672	0.2716	0.2760	0.2805	51.0	25.5	0.1164	0.1171	0.1178	0.1185
14.2	7.1	0.2637	0.2680	0.2723	0.2767	52.0	26.0	0.1157	0.1163	0.1170	0.1177
14.4	7.2	0.2603	0.2645	0.2687	0.2730	53.0	26.5	0.1150	0.1156	0.1162	0.1169
14.6	7.3	0.2569	0.2611	0.2652	0.2694	54.0	27.0	0.1143	0.1149	0.1155	0.1162
14.8	7.4	0.2537	0.2578	0.2619	0.2660	55.0	27.5	0.1136	0.1142	0.1148	0.1155
15.0	7.5	0.2507	0.2546	0.2586	0.2627	56.0	28.0	0.1130	0.1136	0.1142	0.1148
15.2	7.6	0.2478	0.2516	0.2555	0.2595	57.0	28.5	0.1125	0.1130	0.1136	0.1142
15.4	7.7	0.2450	0.2487	0.2524	0.2562	58.0	29.0	0.1120	0.1124	0.1129	0.1134
15.6	7.8	0.2423	0.2459	0.2495	0.2531	59.0	29.5	0.1115	0.1119	0.1124	0.1129
15.8	7.9	0.2397	0.2432	0.2467	0.2501	60.0	30.0	0.1110	0.1114	0.1119	0.1124
16.0	8.0	0.2372	0.2406	0.2440	0.2473						
16.2	8.1	0.2348	0.2381	0.2414	0.2446						
16.4	8.2	0.2325	0.2357	0.2389	0.2420						
16.6	8.3	0.2303	0.2334	0.2365	0.2395						
16.8	8.4	0.2282	0.2312	0.2342	0.2371						
17.0	8.5	0.2262	0.2291	0.2320	0.2348						
17.2	8.6	0.2243	0.2271	0.2300	0.2327						
17.4	8.7	0.2225	0.2252	0.2280	0.2306						
17.6	8.8	0.2208	0.2234	0.2260	0.2285						
17.8	8.9	0.2192	0.2217	0.2242	0.2266						
18.0	9.0	0.2177	0.2201	0.2225	0.2248						

appendix 5

Known addition

$$C_{\text{sam}} = \frac{\rho C_{\text{std}}}{[(1 + \rho) 10^{\frac{\Delta E}{S}} - 1]}$$

Analate addition

$$C_{\text{sam}} = [(1 + \rho) 10^{\frac{\Delta E}{S}} - \rho] C_{\text{std}}$$

Key to terms used:

C_{sam} = sample concentration

ρ = $\frac{\text{volume of standard}}{\text{volume of sample}}$

ΔE = $E_2 - E_1$

S = electrode slope

C_{std} = standard concentration

notice of compliance

This meter may generate radio frequency energy and if not installed and used properly, that is, in strict accordance with the manufacturer's instructions, may cause interference to radio and television reception. It has been type tested and found to comply with the limits for a Class B computing device in accordance with the specifications in Subpart J of Part 15 of FCC Rules, which are designed to provide reasonable protection against such interference in a residential installation. However, there is no guarantee that interference will not occur in a particular installation. If the instrument does cause interference to radio or television reception, which can be determined by turning the unit off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- reorient the receiving antenna
- relocate the meter with respect to the receiver
- move the meter away from the receiver
- plug the meter into a different outlet so that the meter and receiver are on different branch circuits

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet prepared by the Federal Communications Commission helpful:

"How to Identify and Resolve Radio-TV Interference Problems."

This booklet is available from the U.S. Government Printing Office, Washington, DC 20402, Stock No. 004-000-00345-4.

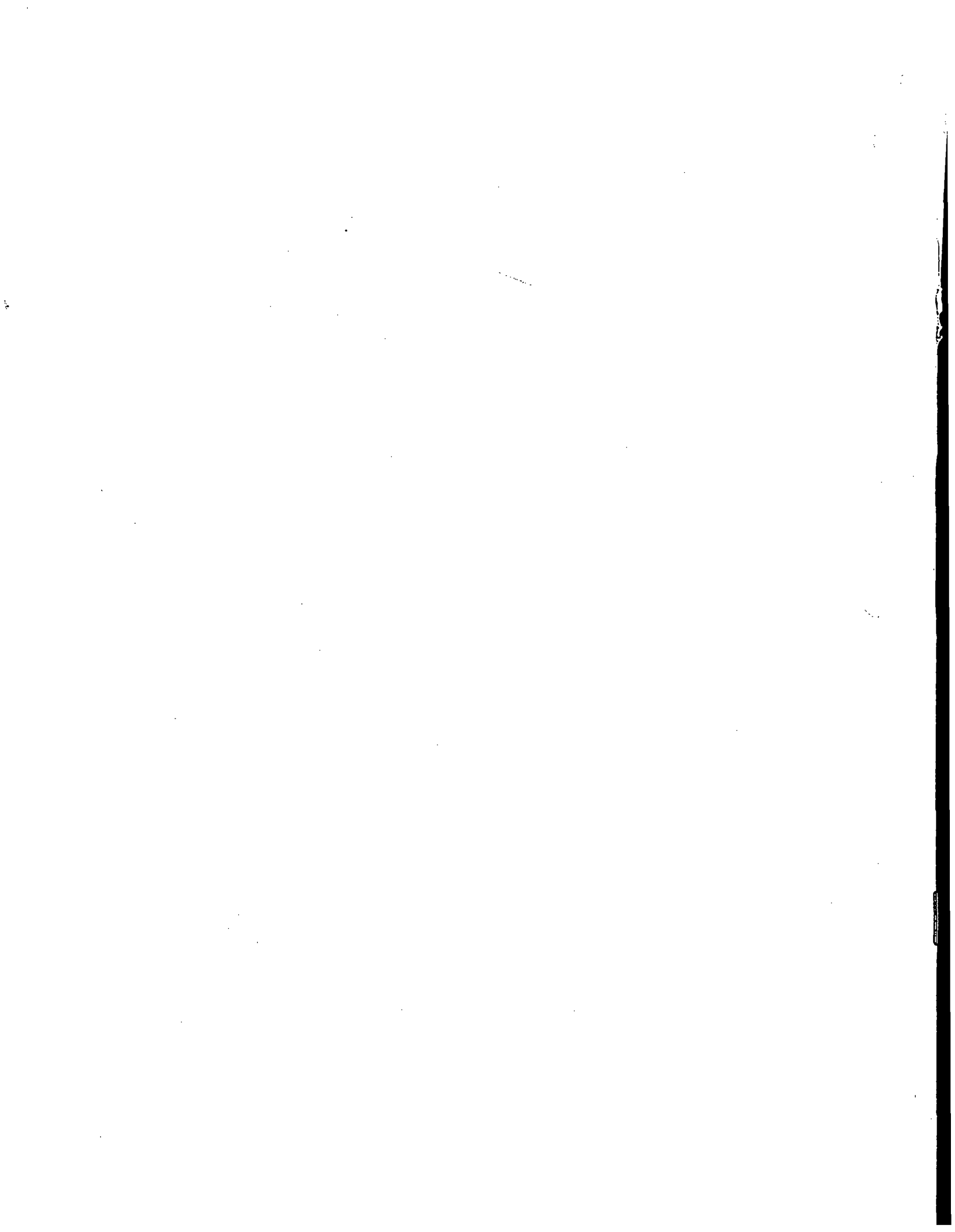
accessories

cat. no.	description
040030	shorting strap
070031	tilt base
070110	automatic temperature compensator
040760	line cord
060500	manual electrode switch
095102	digital printer

specifications

ranges	relative mV: -1999.9 to + 1999.9 mV, approximately ± 200 mV offset absolute mV: - 1999.9 to + 1999.9 mV <i>automatic sign indication</i>
input impedance	10^{13} ohms, minimum
drift	less than $60\mu\text{V}/^\circ\text{C}$
input offset current	less than 1 picoA at 25°C
relative accuracy	± 0.002 pH, ± 0.1 mV, or 0.05% of a reading, whichever is greater
front panel controls	function switch; REL MV, MV, STDBY, pH/.01, pH/.001; calibration control; temperature compensator knob (0 - 100°C); slope indicator (80-100% Nernst slope)
rear panel controls	isopotential point adjust (pH 6-8 nominal), strip-chart recorder span adjust (0 - 100 mV for full range), ATC adjust
rear panel connectors	sensing electrode input, reference electrode input, strip chart recorder output, BCD output, ATC probe input, Karl Fischer polarizing current ($-10\mu\text{A}$), ground jack
power requirements	100/115/220/240V ($\pm 10\%$), 50/60 Hz, 18 watts, CSA approved
case	9 cm high x 33 cm wide x 18 cm deep; steel painted with scratch- and chemical-resistant polyester paint
weight	5 kg

specifications subject to change without notice.



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