WEISS™

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Version 02-05

Part A. General Information

Who is Weiss Research

Weiss Research is a highly energized, research oriented electrochemical sensor manufacturer. It was founded by a group of professional chemists trained in the analytical electrochemical sensor area with more than 60 years of combined experience. Our current main products are pH Electrodes, Ion-Selective Electrodes (ISE), Oxidation-Reduction Potential (ORP), Reference Electrodes, Conductivity Probes, pH buffers, ISE calibration standards & buffers, and accessories.

Mission Statement

Our mission is to satisfy our customers in any possible way and to bring new ideas and innovative tools to our scientific communities. Therefore, the company has been focusing on research and development of new special electrochemical sensors to meet our customers' needs. Besides electrochemical sensors, we design and manufacture specialty sensors and products to meet customer specifications, including private labeling.

Dr. K. L. Cheng

Dr. K. L. Cheng is Professor of Chemistry Emeritus, University of Missouri-Kansas City. He received his B. S. degree from the Northwestern College, China in 1941, his M. S. in 1949, and his Ph.D. in 1951 from the University of Illinois. Dr. Cheng has been a postdoctoral fellow at the University of Illinois and an instructor at the University of Connecticut, Department of Chemistry. Dr. Cheng is a member of the American Chemical Society, Electrochemical Society, American Microchemical Society for Applied Spectroscopy, and American Institute of Physics. He is a fellow of the American Association for Advancement of Science and of the Royal Society of Chemistry, London. He is also a member of Sigma Xi, Sigma Pi Sigma, and Phi Lambda Upsilon.

Dr. Cheng received his RCA Achievement Award in 1963. He was elected titular member of the Division of Analytical Chemistry, International Union of Pure and Applied Chemistry (1969-1979). He received the N. T. Veatch Award for Distinguished Research and Creative Activity and the Certificate of Recognition from the U. S. Office of Naval Research in 1979, and that from the College of Engineering, Texas A&M University, 1981.

He received the Benedetti-Pichler Memorial Award for Microchemistry in 1989. He is the co-author of the "Handbook of Organic Analytical Reagents". He has published chapters in many books and more than 200 papers. He is one of the pioneers of EDTA analytical chemistry. EDTA titration and the use of 1-(2-pyridylazo)- 2-naphthol (PAN) as a metal indicator and photometric reagent were included in his 1951 dissertation. In the past decade, he proposed his double chemical capacitor theory for the ion selective electrodes. He called attention to the misuse of the Nernst equation and disproved the ion exchange reaction between H^+ and Na^+ in the pH glass electrode. He challenged many past misconceptions and emphasized the importance of clear definitions and correct assumptions.

Part B. Laboratory Electrodes & Meters

pH Electrodes

The common characteristics of all Weiss pH electrodes (both lab and process) are:

- Superior Stability - thanks to the special manufacture's knowledge
- Fast response
- Minimum sodium (alkaline) error
- pH 0 -14 full range measurement
- Special internal fill offers full range linear temperature compensation
- Very low sensor glass membrane resistance
- Zero and Isopotential: ~pH 7
- Unique designed electrodes fit almost all kinds of pH meters

SilverCap™ Gel Sealed Epoxy Body pH Electrodes

Weiss ***SilverCap***™, single/double-junction, gel-sealed or refillable Ag/AgCl combination pH electrodes are ***Noise-Free***. They are designed for both laboratory and field use, especially for those application at the strong magnetic field and noisy environment. The unique features of these electrodes provide unparalleled and matchless performances.

Electrode P/N	PHS-0101-3B	PHS-0102-3B	PHS-0201-3B	PHS-0202-3B
Bulb Shape	Ball	Ball	Ball	Ball
Body Material/Color	Epoxy / Blue	Epoxy / Blue	Epoxy / Blue	Epoxy / Blue
Type of Reference	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl
Sealed/Refillable	Gel-Sealed	Refillable	Gel-Sealed	Refillable
pH range	0-14	0-14	0-14	0-14
Junction Material	Ceramic wick	Ceramic wick	Ceramic wick	Ceramic wick
Junction type	Single	Single	Double	Double
Max Temp. (°C)	80	80	80	80
Dimensions (mm)	12 x 115	12 x 115	12 x 115	12 x 115
Cable length (m)	1.0 m	1.0 m	1.0 m	1.0 m
Connector	BNC	BNC	BNC	BNC
List Price (US$)	$45.00	$45.00	$56.00	$56.00

ElectroJelly™ Filled (sealed) Epoxy/ Glass Body pH Electrodes

ElectroJelly™ is a solid material with highly concentrated salt (most time it is KCl). Because the ElectroJelly™ can effectively hold reference electrode electrolytes and prevent it from being contaminated by sample back-flow, the ElectroJelly™ filled (sealed) electrodes can easily accomplish longer life and less calibration goal (compared to regular gel filled electrodes).

The ElectroJelly™ filled electrodes are most suitable for 24/7 monitoring applications with temperature cycling changes such as swimming pools, aquariums and industrial processing. When it is adopted under normal laboratory conditions, the performance is even better.

ElectroJelly™ Filled pH Electrode

Electrode P/N	PHS-0181-3B	PHS-0281-3B	PH5101-3B	PH5112-3B
Bulb Shape	Ball	Ball	Ball	Ball
Body Material/Color	Epoxy / Blue	Epoxy / Blue	Glass	Glass
Type of Reference	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl
Sealed/Refillable	EJ-Sealed	EJ-Sealed	EJ-Sealed	EJ-Sealed
pH range	0-14	0-14	0-14	0-14
Junction Material	Ceramic wick	Ceramic wick	Annular	Annular
Junction type	Single	Double	Single	Double
Max Temp. (°C)	80	80	100	100
Dimensions (mm)	12 x 115	12 x 115	12x120	12x120
Cable length (m)	1.0	1.0	1.0	1.0
Connector	BNC	BNC	BNC	BNC
List Price (US$)	$48.00	$59.00	$63.00	$78.00

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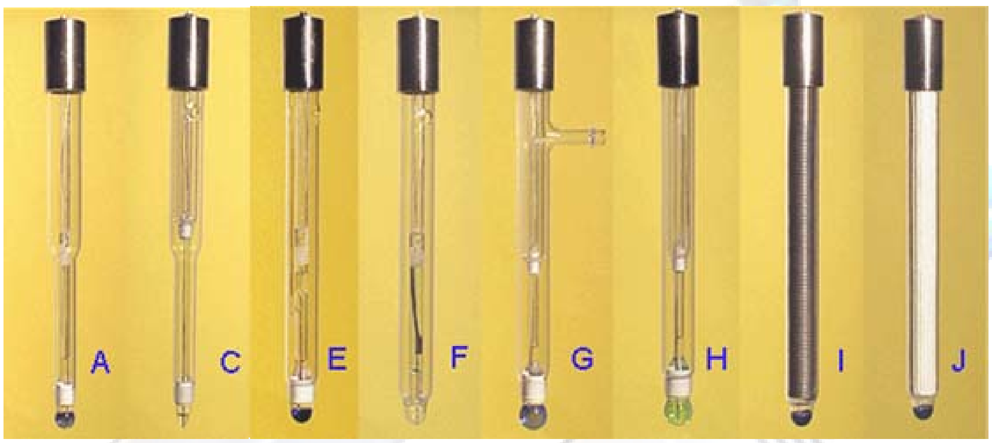
SilverCap™ Glass body pH Electrodes

Common features of Weiss Glass-body pH electrodes:

- Ag/AgCl reference electrode if applicable
- pH range 0-14
- Annular Ceramic Junction except electrode F which is wick.
- Temperature Range 0 -100 °C
- BNC connector with 1 meter low-noise cable. Other connectors and cable length are available, please specify when ordering.



P/N	Fig.	Half / Combo	Bulb Shape	Sealed / Refillable	Junction type	Dimensions mm	Price US$
PH5001-3B	E	Combo	Ball	Sealed	Single	12 x 120	$59.00
PH5005-3B	E	Combo	Ball	Refillable	Single	12 x 120	$59.00
PH5007-3B	E	Combo	Dome	Refillable	Single	12 x 120	$59.00
PH5009-3B	E	Combo	Dome	Sealed	Single	12 x 120	$59.00
PH5012-3B	H	Combo	Ball	Sealed	Double	12 x 120	$75.00
PH5016-3B	H	Combo	Ball	Refillable	Double	12 x 120	$75.00
PH5020-3B	A	Combo	Ball	Refillable	Double	8.2x60	$99.00
PH5025-3B	A	Combo	Ball	Sealed	Single	8.2x60	$85.00
PH5027-3B	A	Combo	Ball	Refillable	Single	8.2x60	$85.00
PH5028-3B	A	Combo	Ball	Sealed	Double	8.2x60	$99.00
PH5040-3B	C	Combo	Spear	Refillable	Double	8.2x65	$109.00
PH5045-3B	C	Combo	Spear	Sealed	Single	8.2x65	$99.00
PH5047-3B	C	Combo	Spear	Refillable	Single	8.2x65	$99.00
PH5048-3B	C	Combo	Spear	Sealed	Double	8.2x65	$109.00
PH5065-3B	F	Combo	Dome	Refillable	Single	12 x 120	$76.00
PH5067-3B	F	Combo	Ball	Refillable	Single	12 x 120	$76.00
PH5070-3B	G	Combo	Ball	Refillable	Double	12 x 120	$128.00
PH5077-3B	G	Combo	Ball	Refillable	Single	12 x 120	$118.00
PH5081-3B	I	Half	Ball	N/A	N/A	12 x 120	$76.00
PH5083-3B	J	Half	Dome	N/A	N/A	12 x 120	$76.00

Detachable Cable pH Electrodes

Common features of Weiss Detachable Cable pH electrodes:

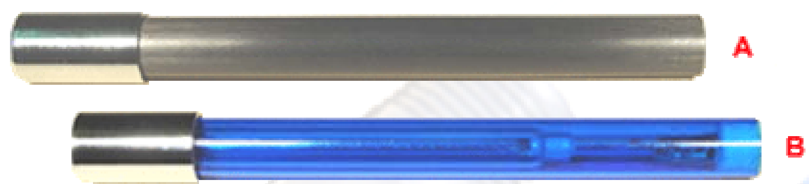
- Ag/AgCl reference electrode
- pH range 0-14
- Ceramic Junction
- Temperature Range: 0 -100 °C for glass body; 0-80 °C for epoxy and graphite body
- Dimension: 12 x115 mm exclude cap
- BNC connector with 1 meter low-noise cable. Other connectors and cable length are available, please specify when ordering.

Electrode P/N	Fig.	Body Material	Bulb Shape	Junction type	Sealed/ refillable	Sealed Electrolyte	Price
PHD-1301	A	Epoxy / Blue	Ball	Single	Sealed	Gel	$42.00
PHD-1302	A	Epoxy / Blue	Ball	Double	Sealed	Gel	$59.00
PHD-1305	A	Epoxy / Blue	Ball	Single	Refillable	-	$42.00
PHD-1306	A	Epoxy / Blue	Ball	Double	Refillable	-	$59.00
PHD-1307	A	Epoxy / Blue	Ball	Single	Sealed	ElectroJelly™	$48.00
PHD-1308	A	Epoxy / Blue	Ball	Double	Sealed	ElectroJelly™	$68.00
PHD-1311	B	Graphite	Flat	Single	Sealed	ElectroJelly™	$55.00
PHD-1312	B	Graphite	Flat	Double	Sealed	ElectroJelly™	$68.00
PHD-1321	C	Glass	Ball	Single	Sealed	Gel	$63.00
PHD-1322	C	Glass	Ball	Double	Sealed	Gel	$78.00
PHD-1325	C	Glass	Ball	Single	Refillable	-	$65.00
PHD-1326	C	Glass	Ball	Double	Refillable	-	$78.00
PHD-1327	C	Glass	Ball	Single	Sealed	ElectroJelly™	$66.00
PHD-1328	C	Glass	Ball	Double	Sealed	ElectroJelly™	$79.00
TB-3	TNC to BNC converter with 3 feet low noise cable						$19.00

Flat Membrane pH Electrodes

Common features of Weiss Flat pH electrodes:

- Ag/AgCl reference electrode
- pH range 0-14
- Ceramic Junction
- Temperature Range: 0-80 °C
- Dimension: 12 x115 mm exclude cap
- BNC connector with 1 meter low-noise cable. Other connectors and cable length are available, please specify when ordering.



Electrode P/N	PHF-1311-3B	PHF-1312-3B	PHF-0101-3B	PHF-0181-3B	PHF-0281-3B
Figure	A	A	B	B	B
Body Material	Graphite	Graphite	Epoxy / Blue	Epoxy / Blue	Epoxy / Blue
Junction type	Single	Double	Single	Single	Double
Sealed/Refillable	Sealed	Sealed	Sealed	Sealed	Sealed
Sealed Electrolyte	ElectroJelly™	ElectroJelly™	Gel	ElectroJelly™	ElectroJelly™
List Price (US$)	$52.00	$65.00	$45.00	$49.00	$62.00

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Triune™ (3-in-1) pH Electrodes

Weiss ***Triune***™ (3-in-1) either gel or ElectroJelly™ (E-Jelly™) sealed pH electrodes are combined with pH, reference, and temperature electrodes together to offer a simple tool for applications which require Automatic Temperature Compensation (ATC) for its measurement. If the application requires continued monitoring of the pH value of the sample stream, the ElectroJelly™ sealed pH electrode is the best choice.

Common features of ***Triune***™ pH electrodes:

- Epoxy Body, Noise-Free
- Ag/AgCl reference electrode if applicable
- pH range 0-14
- Ceramic wick junction
- Temperature Range 0 - 80 °C
- 1 meter cable with BNC connector for pH probe and phone connector for ATC. Other connectors and cable length are available, please specify when ordering.
- Available temperature sensors are Pt100, Pt1000, 30K and 10K. Other thermostats are available, please specify when ordering.

Part #	Ref. fill	T. Sensor	Junction	Price
PHT3100-3BP	Gel	Pt 100	Single	$75.00
PHT3200-3BP	Gel	Pt 1000	Single	$75.00
PHT3300-3BP	Gel	10 k	Single	$69.00
PHT3400-3BP	Gel	30 k	Single	$69.00
PHT3118-3BP	E-Jelly™	Pt 100	Single	$78.00
PHT3218-3BP	E-Jelly™	Pt 1000	Single	$78.00
PHT3318-3BP	E-Jelly™	10 k	Single	$72.00
PHT3418-3BP	E-Jelly™	30 k	Single	$72.00
PHT3188-3BP	E-Jelly™	Pt 100	Double	$93.00
PHT3288-3BP	E-Jelly™	Pt 1000	Double	$93.00
PHT3388-3BP	E-Jelly™	10 k	Double	$89.00
PHT3488-3BP	E-Jelly™	30 k	Double	$89.00

Really-Flow™ pH Electrodes

Weiss Really-Flow™ combination pH electrodes have a free flowing junction, provide optimal flow rate (adjustable), resulting in better reproducibility. The junction design permits easy cleaning, which improves performance and extends the electrode's life. These long-lasting electrodes have no ceramic or fiber junction to clog. Viscous and dirty samples are no problems for the electrodes. Just press down on the cap to open the sleeve and flush, renew the junction; release the cap and you are ready to take more measurements.

The common characteristics of Weiss Really-Flow™ combination electrodes are:

- Rugged epoxy body
- Easy to clean, no clogging problems
- Adjustable junction flow rate
- Fast, accurate and incredibly stable
- Long electrode life
- Useful in abrasive, viscous and dirty samples (e.g. slurry)
- Ready to use, no further soaking needed

Electrode P/N	PHR-1002-3B
Electrode Grade	General Purpose
Body Material/Color	Epoxy / Amber
Type of Reference	Ag/AgCl
Sealed/Refillable	Refillable
pH range	0-14
Junction Material	Sleeve-type
Junction type	Single
Max Temp. (°C)	80
Dimensions (mm)	13 x 120
Cable length (m)	1.0 m
Connector	BNC
Price	$75.00

GA-13 (glass bulb protection guard for 13 mm diameter electrodes)……….. $5.00

ElectroJelly™ and Gel Filled (sealed) Epoxy body ORP Electrodes

Unlike pH electrodes which can be calibrated and adjusted by meters, ORP electrodes are difficult to be standardized by most pH/mV meters. Keeping constant reference potential is the key to successful ORP measurement. To fulfill this requirement, the ElectroJelly™ filled (sealed) electrodes were developed. ElectroJelly™ is a solid material with highly concentrated salt (most time it is KCl). Because the ElectroJelly™ can effectively hold reference electrode electrolytes against sample back-flow and contamination, the ElectroJelly™ filled (sealed) electrodes can easily accomplish stable reference potential, longer life and less calibration goal (compared to regular gel filled electrodes). The ElectroJelly™ filled electrodes are most suitable for the 24/7 monitoring applications with temperature cycling changes such as swimming pools, aquariums and industrial processing. It is even better when it is used under normal laboratory conditions.

The common characteristics of Weiss combination, sealed or refillable Ag/AgCl single-junction (SJ) and Double-Junction (DJ) ORP Electrodes are:

- Platinum rod sensor
- Rugged epoxy body
- Fast, accurate and incredibly stable
- Long electrode life
- Ready to use, no further soaking needed
- Ceramic Junction
- Temperature Range: 0-80 °C
- Dimension: 12 x115 mm exclude cap
- BNC connector with 1 meter low-noise cable. Other connectors and cable length are available, please specify when ordering.

Part #	Ref. fill	Junction	Price
ORP-1011-3B	Gel	SJ	$89.00
ORP-1012-3B	Refillable	SJ	$89.00
ORP-1081-3B	ElectroJelly™	SJ	$94.00
ORP-1088-3B	ElectroJelly™	DJ	$108.00

Detached cable ORP Electrodes

The common characteristics of Weiss detached cable combination, sealed Ag/AgCl single-junction (SJ) and Double-Junction (DJ) ORP Electrodes are:

- Platinum rod sensor
- Rugged epoxy body
- Fast, accurate and incredibly stable
- Long electrode life
- Ready to use, no further soaking needed
- Ceramic Junction
- Temperature Range: 0-80 °C
- Dimension: 12 x115 mm exclude cap
- TNC to BNC convert cable (1 meter low-noise cable). TNC to other connectors and cable length are available, please specify when ordering.

Part #	Ref. fill	Junction	Price
ORP-3011-TN	Gel	SJ	$92.00
ORP-3081-TN	ElectroJelly™	SJ	$96.00
ORP-3088-TN	ElectroJelly™	DJ	$110.00
TB-3	converts TNC to BNC, length 1 meter		$19.00

Really-Flow™ ORP Electrodes (Flat)

Weiss Really-Flow™ combination, single-junction ORP electrodes have a free flowing junction (sleeve), provide optimal flow rate (adjustable), resulting in better reproducibility. The easy clean sensor surface (another key for successful ORP measurement) and junction designing ensure the performances and long electrodes life. These long-lasting electrodes have no ceramic or fiber junction to clog. They are the ideal tools for viscous and dirty samples.

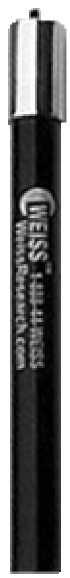
Electrode P/N	ORP-0100-3B	ORP-0200-3B
Sensing Material	Platinum disc	Gold disc
Body Material/Color	Epoxy / Amber	Epoxy / Amber
Type of Reference	Ag/AgCl	Ag/AgCl
Max Temp. (°C)	80	80
Dimensions (mm)	13 x 110	13 x 110
Cable length (m)	1.0 m	1.0 m
Connector	BNC	BNC
Price (US$)	$179.50	$179.50

Ion-Selective Electrodes (ISE)

Gas Sensor - Ammonia

Electrode	Ammonia (NH_3)
Part Number	NH3003
Sensor type	Gas
Sensor Membrane	Teflon
Limits, ppm	17000 ~0.02
pH range	11 ~13
Interferences	Hydrazine
Calibration Std	1000 ppm as N
ISA	10 *M* NaOH
Reference	Ag/AgCl
Junction	-
Fill solution	0.1 M NH4Cl
Cable Length	1 meter
Connector	BNC
Price	$220.00

Half-cell, solid-State Ion-Selective Electrodes (has to be used with a reference electrode)



Half-cell, solid-state ion-selective electrodes are constructed by a highly chemical resistance epoxy body and specially formulated sensor material for lasting and accurate performance. The half-cell electrode features are easy-to-use and require low maintenance. These solid half-cell ion-selective electrodes are required to be used with a reference electrode. The ideal reference electrodes are Weiss Carry-over Contamination Free or Sleeve-type or double-junction glass body reference electrodes. Please check reference electrode section.

The common features of these half-cell ISEs are:

- Rugged epoxy body
- Max temperature: 80 °C
- Dimension: 12 x110mm exclude cap
- BNC connector with 1 meter low-noise cable. Other connectors and cable length are available, please specify when ordering.

Electrode P/N	WBR1001	WCD1001	WCL1001
Type of Electrode	Bromide (Br^-)	Cadmium (Cd^{++})	Chloride (Cl^-)
Body Material/Color	Epoxy / Black	Epoxy / Black	Epoxy / Black
Conc. range (ppm)	0.4 - 79900	0.01 - 11200	1.8 - 35500
Conc. range (*M*)	5 x 10^(-6) - 1.0	10^(-7) - 0.1	5 x 10^(-5) - 1.0
Interferences	I-, S=, CN- and high level of Cl-, NH3	Hg++, Ag+, Cu++ must be absent. high level of Pb++ and Fe++	CN-, Br-, I-, OH-; S= must be absent
pH range	2 ~ 14	2 ~ 12	2 ~ 12
Reference fill solution	1 M KNO3	1 M KNO3	1 M KNO3
Price (US$)	$99.00	$120.00	$99.00

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Electrode P/N	WCU1001	WCN1001	WF01001
Type of Electrode	Copper (II) (Cu^{++})	Cyanide (CN^-)	Fluoride (F^-)
Body Material/Color	Epoxy / Black	Epoxy / Black	Epoxy / Black
Conc. range, ppm	0.00064 - 6350	0.1 - 260	0.02 - saturated
Conc. range, *M*	10^(-8) - 0.1	8 x 10^(-6) - 0.01	10^(-6) - saturated
Interferences	Hg++, Ag+ must be absent; high levels of Fe++, Br- and Cl- may interfere	I-, Br-, Cl-; S= must be absent	OH-
pH range	2 ~ 12	11 ~ 13	5 ~ 11
Reference fill solution	1 M KNO3	1 M KNO3	4 M KCl
Price (US$)	$120.00	$99.00	$150.00

Electrode P/N	WI01001	WAG1001	WPB1001	WS21001
Type of Electrode	Iodide (I^-)	Silver (Ag^+)	Lead (Pb^{++})	Sulfide ($S^=$)
Body Material/Color	Epoxy / Black	Epoxy / Black	Epoxy / Black	Epoxy / Black
Conc. range, ppm	0.006 - 127000	0.01 - 107900	0.2 -20700	0.003 - 32100
Conc. range, *M*	5 x 10^(-8) - 1.0	10^(-7) - 1	10^(-6) - 0.1	10^(-7) - 1
Interferences	CN-, S2O3=, S=, NH3	Hg++	Hg++, Ag+ and Cu++ must be absent; high levels of Fe++, Cd++ may interfere	Hg++
pH range	0 ~ 14	2 ~ 12	3 ~ 8	2 ~ 12
Reference fill solution	1 M KNO3	1 M KNO3	1 M KNO3	1 M KNO3
Price (US$)	$99.00	$99.00	$120.00	$99.00

Really-Flow™ Solid-State combination Ion-selective Electrodes

Weiss Really-Flow™ combination Ion-selective electrodes have a free flowing junction and provide optimal flow rate (adjustable), resulting in more accuracy and repeatability. The junction design permits easy cleaning, which improves performance and extends the electrode's life. These long-lasting electrodes have no ceramic or fiber junction to clog. Viscous and dirty samples are no problems for the electrodes. Just press down on the cap to open the sleeve and flush, renew the junction; release the cap and you are ready to take more measurements. Also, the Really-Flow™ ISEs have a small volume measurement feature.

The common characteristics and features of Really-Flow™ combination ISEs are:

- Rugged epoxy body
- Single Junction, refillable Ag/AgCl reference cell
- Easy to clean, no clogging problems
- Adjustable junction flow rate
- Fast, accurate and incredibly stable readings
- Long electrode life
- Useful in abrasive, viscous and dirty samples (e.g. slurry)
- Max temperature: 80 °C
- Dimension: 12 x110mm exclude cap
- BNC connector with 1 meter low-noise cable. Other connectors and cable length are available, please specify when ordering.

Electrode P/N	RBR3001	RCD3001	RCL3001
Type of Electrode	Bromide (Br^-)	Cadmium (Cd^{++})	Chloride (Cl^-)
Body Material/Color	Epoxy / Amber	Epoxy / Amber	Epoxy / Amber
Junction Material	Sleeve	Sleeve	Sleeve
Conc. range, ppm	0.4 - 79900	0.01 - 11200	1.8 - 35500
Conc. range, *M*	5 x 10^(-6) - 1.0	10^(-7) - 0.1	5 x 10^(-5) - 1.0
Interferences	I-, S=, CN- and high level of Cl-, NH3	Hg++, Ag+, Cu++ must be absent. high level of Pb++ and Fe++	CN-, Br-, I-, OH-; S= must be absent
pH range	2 ~ 14	2 ~ 12	2 ~ 12
Reference fill solution	1 M KNO3	1 M KNO3	1 M KNO3
Price (US$)	$179.00	$198.00	$179.00

Electrode P/N	RCU3001	RCN3001	RF03001
Type of Electrode	Copper (II) (Cu^{++})	Cyanide (CN^{-})	Fluoride (F^{-})
Body Material/Color	Epoxy / Amber	Epoxy / Amber	Epoxy / Amber
Junction Material	Sleeve	Sleeve	Sleeve
Conc. range, ppm	0.00064 - 6350	0.1 - 260	0.02 - saturated
Conc. range, *M*	10^(-8) - 0.1	8 x 10^(-6) - 0.01	10^(-6) - saturated
Interferences	Hg++, Ag+ must be absent; high levels of Fe++, Br- and Cl- may interfere	I-, Br-, Cl-; S= must be absent	OH-
pH range	2 ~ 12	11 ~ 13	5 ~ 11
Reference fill solution	1 M KNO3	1 M KNO3	4 M KCl
Price (US$)	$198.00	$179.00	$220.00

Electrode P/N	RI03001	RAG3001	RPB3001	RS23001
Type of Electrode	Iodide (I^{-})	Silver (Ag^{+})	Lead (Pb^{++})	Sulfide ($S^{=}$)
Body Material/Color	Epoxy / Amber	Epoxy / Amber	Epoxy / Amber	Epoxy / Amber
Junction Material	Sleeve	Sleeve	Sleeve	Sleeve
Conc. range, ppm	0.006 - 127000	0.01 - 107900	0.2 -20700	0.003 - 32100
Conc. range, *M*	5 x 10^(-8) - 1.0	10^(-7) - 1	10^(-6) - 0.1	10^(-7) - 1
Interferences	CN-, S2O3=, S=, NH3	Hg++	Hg++, Ag+ and Cu++ must be absent; high levels of Fe++, Cd++ may interfere	Hg++
pH range	0 ~ 14	2 ~ 12	3 ~ 8	2 ~ 12
Reference fill	1 M KNO3	1 M KNO3	1 M KNO3	1 M KNO3
Price (US$)	$179.00	$179.00	$198.00	$179.00

Glass-body Solid-state Combination Ion-selective Electrodes

The glass body solid-state ion-selective electrodes have the same chemistry characteristics as half-cell or Really-Flow™ electrodes; please see these sections as a reference.

The common features of these electrodes are:

- Double Junction, refillable or sealed Ag/AgCl reference cell
- Max temperature: 100 °C
- Dimension: 12 x120mm exclude cap
- BNC connector with 1 meter low-noise cable. Other connectors and cable lengths are available, please specify when ordering.

Part #	Refill / Sealed	Fill solution	Price
BR3005	Refillable	10% KNO3	$218.00
BR3008	Sealed	--	$218.00
CD3005	Refillable	10% KNO3	$238.00
CD3008	Sealed	--	$238.00
CL3005	Refillable	10% KNO3	$218.00
CL3008	Sealed	--	$218.00
CU3005	Refillable	10% KNO3	$238.00
CU3008	Sealed	--	$238.00
CN3005	Refillable	10% KNO3	$218.00
CN3008	Sealed	--	$218.00
I03005	Refillable	10% KNO3	$218.00
I03008	Sealed	--	$218.00
AG3005	Refillable	10% KNO3	$218.00
AG3008	Sealed	--	$218.00
PB3005	Refillable	10% KNO3	$238.00
PB3008	Sealed	--	$238.00
S23005	Refillable	10% KNO3	$218.00
S23008	Sealed	--	$218.00

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PVC Membrane Ion-selective Electrodes

The electrodes in this section are all made by other companies except ammonia electrodes which are manufactured by Weiss.

S7 or Screw Connectors are available. The price for combination S7 connector electrodes are $375.00 instead $390.00, but a separate cable is required. For the Half-cell electrodes, the separate reference electrodes are needed. For information of reference electrodes, please see "Reference Electrodes" section.

Electrode	Ammonium (NH_4^+)	Barium (Ba^{+2})	Calcium (Ca^{+2})
Sensor type	PVC "dry" Contact	PVC "dry" Contact	PVC "dry" Contact
Body Material	Epoxy	Epoxy	Epoxy
Limits, ppm	9000 ~0.9	13700 ~1.4	4010 ~0.02
pH range	0 ~8.5	3 ~10	3.5 ~11
Main Interferences	K^+	K^+, Na^+, Sr^{+2}	Ba^{+2} Sr^{+2} Al^{+3}
Calibration Standard	1000 ppm as NH_4^+	1000 ppm as Ba^{+2}	1000 ppm as Ca^{+2}
ISA	5M NaCl	4M KCl	4M KCl
Type of Reference	Ag/AgCl	Ag/AgCl	Ag/AgCl
Junction	Double	Double	Single
Reference fill solution	0.1 M NaCl	1 M NH_4NO_3	***
Cable Length	1 meter	1 meter	1 meter
Connector	BNC	BNC	BNC
P/N, Combination	3051BN	3081BN	3041BN
Price, Combination	$390.00	$390.00	$390.00
P/N, Half-Cell	1051BN	1081BN	1041BN
Price, Half-Cell	$290.00	$290.00	$290.00

Electrode	Carbonate (CO_3^{-2})	Fluoroborate (BF_4^-)	Nitrate (NO_3^-)	Nitrite (NO_2^-)
Sensor type	PVC "dry" Contact	PVC "dry" Contact	PVC "dry" Contact	PVC "dry" Contact
Body Material	Epoxy	Epoxy	Epoxy	Epoxy
Limits, ppm	80 ~0.008	86800 ~ 0.7	62000 ~0.4	460 ~0.5
pH range	6.6 ~9.6	2 ~ 11	2 ~11	4.6 ~ 8
Main Interferences	OAc^- SCN^-	Cl^-, OAc^-, $H_2PO_4^-$, HCO_3^-	Cl^- NO_2^-	CN^-
Calibration Standard	100 ppm as CO_3^{-2}	1000 ppm as BF_4^-	1000 ppm as NO_3^-	1000 ppm as NO_2^-
ISA	**	2*M* $(HN_4)_2SO_4$	$KAl(SO_4)_2 12H_2O$	$KAl(SO_4)_2 12H_2O$
Type of Reference	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl
Junction	Single	Double	Double	Single
Reference fill solution	***	0.1*M* $(HN_4)_2SO_4$	0.1*M* $KAl(SO_4)_2$	***
Cable Length	1 meter	1 meter	1 meter	1 meter
Connector	BNC	BNC	BNC	BNC
P/N, Combination	3091BN	-	3021BN	3071BN
Price, Combination	$390.00	-	$390.00	$390.00
P/N, Half-Cell	1091BN	1028BN	1021BN	1071BN
Price, Half-Cell	$290.00	$290.00	$290.00	$290.00

Electrode	Perchlorate (ClO_4^-)	Potassium (K^+)	Water Hardness	Sodium (Na^+)
Sensor type	PVC "dry" Contact	PVC "dry" Contact	PVC "dry" Contact	Glass
Body Material	Epoxy	Epoxy	Epoxy	Glass
Limits, ppm	99500 ~0.2	39000 ~0.04	-	69000 ~0.002
pH range	0 ~ 11	1 ~ 9	4.5 ~10	9 ~ 12
Main Interferences	I^- SCN^- NO_3^-	Cs^+, NH_4^+	Ba^{+2} Sr^{+2} Al^{+3}	Li^+ K^+ Ba^{+2}
Calibration Standard	1000 ppm as ClO_4^-	1000 ppm as K^+	1000 ppm as Ca^{+2}	1000 ppm as Na^+
ISA	2*M* $(HN_4)_2SO_4$	5*M* NaCl	4*M* KCl	4*M* NH_4Cl
Type of Reference	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl
Junction	Double	Double	Single	*
Reference fill solution	0.1*M* $(HN_4)_2SO_4$	0.1*M* NaCl	***	-
Cable Length	1 meter	1 meter	1 meter	1 meter
Connector	BNC	BNC	BNC	BNC
P/N, Combination	3061BN	3031BN	3100BN	3401BN
Price, Combination	$390.00	$390.00	$390.00	$185.00
P/N, Half-Cell	1061BN	1031BN	1100BN	-
Price, Half-Cell	$290.00	$290.00	$290.00	-

* Not required
** Custom-formulated solution
*** Custom-formulated solution required if using DJ reference electrodes

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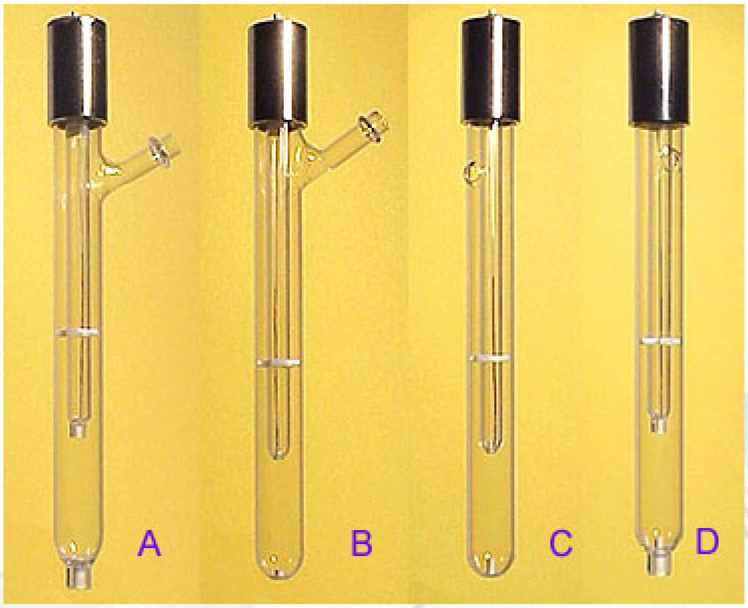
Reference Electrodes

Glass Body Double Junction Electrodes

Weiss Glass body Double-Junction Reference Electrodes are designed for working with Ion-selective, pH, ORP electrodes, and potentiostats. Side-arm electrodes are the ideal for titration.



Electrode P/N	RE6090	RE6092	RE6094	RE6096	RE6097	RE6099
Figure	A	B	C	D	D	D
Sealed/Refillable	Refillable	Refillable	Refillable	Refillable	Sealed*	Refillable
Type of Reference	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl
Junction Material	Ceramic wick	Ceramic wick	Ceramic wick	Ceramic wick	Ceramic wick	Ceramic wick
Junction type	Double	Double	Double	Double	Double	Single
Max Temp. (°C)	100	100	100	100	100	100
Dimensions (mm)	12 x 110	12 x 110	12 x 110	12 x 110	12 x 110	12 x 110
Cable length (m)	1.0	1.0	1.0	1.0	1.0	1.0
Connector	PIN	PIN	PIN	PIN	PIN	PIN
Price (US$)	$105.00	$105.00	$78.00	$78.00	$78.00	$50.00

* 4 M KCl gel solution is filled as default. For other fillers, please specify when ordering.

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WEISS™

Carry-over Contamination Free and Really-Flow™ Reference Electrodes

Weiss Really-Flow™ and Contamination-Free, Double-Junction Reference Electrodes are designed for working with Ion-selective electrodes. The Contamination-Free, Double-Junction Reference Electrodes come in two versions; epoxy body with Teflon ceramic tips for a general purpose, and glass body with Teflon ceramic tips for samples with organic solvents. Both electrodes have the changeable or replaceable ceramic wick junction. With a changeable or replaceable junction, the electrode can completely eliminate the "carry over" contamination and junction clog problems of a traditional reference electrode. For instance, a reference electrode with a ceramic wick saturated with KCl is not applicable to the measurement of chloride and potassium ions since it will interfere with the measurement by releasing KCl from the ceramic wick into the sample. With Contamination-Free reference electrodes, the ceramic wick junction can easily be changed to, for example, a chloride-free ceramic tip. Another advantage is that when the reference junction is clogged by the sample or other materials, it's no problem at all, just simply replace it with a new ceramic junction. These Contamination-Free reference electrodes can be used for any combination with ion-selective electrodes including pH without contaminating sample solutions. It is also very economical because one reference electrode can work for many different ion measurements.

Both epoxy and glass body Carry-over Contamination Free reference electrodes come with 2 Teflon ceramic tips.

Electrode P/N	WRE5001	WRE5002	WRR5010	WRR5012
Type of Electrode	Carry-over Contamination Free	Carry-over Contamination Free	Really-Flow™	Really-Flow™
Body Material/Color	Epoxy / Amber	Glass	Epoxy / Amber	Epoxy / Amber
Sealed/Refillable	Refillable	Refillable	Refillable	Refillable
Type of Reference	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl
Junction Material	Changeable Teflon Ceramic wick	Changeable Teflon Ceramic wick	Sleeve	Sleeve
Junction type	Double	Double	Single	Double
Max Temp. (°C)	80	100	80	80
Dimensions (mm)	12 x 120	12 x 120	13 x 110	13 x 110
Cable length (m)	1.0	1.0	1.0	1.0
Connector	PIN	PIN	PIN	PIN
Price (US$)	$75.00	$75.00	$85.00	$95.00

C-tip-200	Teflon	for WRE5001	$20.00
C-tip-300	Teflon	for WRR5002	$20.00

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Meters - these meters are other company's products.

Ion/ pH/ ORP/ mV/ Temp. Meter – Model 6250

- pH buffer recognition: pH 7.00, 4.01 & 10.01
- High resolution: 0.001/0.01 pH; 0.1/1.0 mV (selectable)
- Direct readout in ion concentration
- RS-232 output
- CE approved
- Auto/manual temp. compensation
- Splash resistant/Watertight case
- Highly reliable mechanical touch keys with tactile & audio feedback
- Power down memory backup
- battery/AC adaptor
- High 50/60 Hz AC noise rejection

6250-meter, pH/mV(ORP)/Ion/temp Meter........... $395.00
6250-ATC, temp. probe, 10 K Ohm, 3ft cable....... $69.00

Specifications

	Range	Resolution	Accuracy
pH	-2.000 to +16.000 pH	0.001/0.01	±0.1% ±1 digit
mV	-1999.9 to +1999.9	0.1/1.0 mV	±0.1% ±1 digit
Temp.	-5.0 to +125.0 °C	0.1 °C	±0.5 °C
Ion	0.000 to 19900	±one least significant digit	±2 LSD

pH temp. compensation	Auto/Manual: -5.0 to +125.0 °C
pH buffer temp. range	0 to 50 °C
pH electrode offset recognition	±90 mV
pH electrode slope recognition	±30%
pH standardization	Single or dual point
Ion standardization	Single point
Input impedance	$>10^{13}$ Ohm
ATC probe	Thermistor (10K Ohm at 25 °C)
Communication	RS232C output
Power back	Memory Backup
Audio Feedback	All touch keys
Display: pH/mV ¦ Temp	15 mm ¦ 8.7 mm high LCD
Ambient temp. range	0 to 50 °C
Power supply: batteries/adaptor	6 AAA batteries/115V or 230V AC
Battery life (alkaline)	~25 hrs
Dimensions (W x L x H)	83 x 421 x 71 mm
Weight	450 gm (batteries included)

pH/ ORP/mV/ Temp. Meter - Model 6027

Model 6027 pH / ORP/ mV /Temp Meter......... $195.00

Accessories:
SilverCap™ Noise-Free, pH Electrode $39.00
Temperature Probe, Glass body, 3ft cable.......$49.00
Temp. Probe, Stainless steel body, 3ft cable....$69.00

	RANGE	RESOLUTION	ACCURACY
pH	-2.00 to +16.00 pH	0.01 pH	±0.01 ±1 digit
mV	-1999 to +1999 mV	1 mV	±0.1% ±1 digit
TEMP °C	-5.0 to +125.0 °C	0.1 °C	±0.5 °C

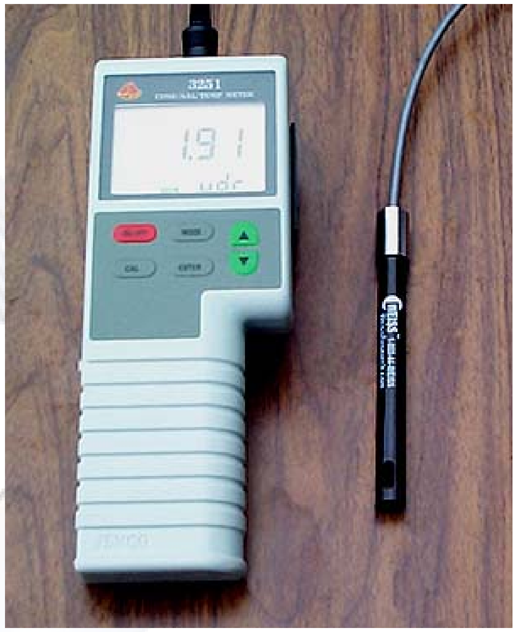
pH TEMP. COMPENSATION	AUTO/MANUAL -5.0 to 125.0 °C
pH BUFFER TEMP. RANGE	0 to 60 °C
pH ELECTRODE OFFSET RECOGNITION	±90 mV
pH ELECTRODE SLOPE RECOGNITION	±30 %
INPUT IMPEDANCE	$>10^{12}$ Ω
ATC PROBE	Thermistor (10K Ω at 25 °C)
DUAL POINT STANDARDIZATION	Yes
END POINT SENSING & HOLD	Yes
POWER BACKUP	Memory Backup
AUDIO FEEDBACK	All Touch Keys
DISPLAY - pH / mV : Temp	12.5 mm : 7.5 mm High LCD
AMBIENT TEMP. RANGE	0 to 50 °C
RELATIVE HUMIDITY	Up to 90 %
POWER SUPPLY- Battery/Adaptor	Single 9V Battery/ 115V or 230V AC Adaptor
DIMENSIONS (L x W x H)	150 mm x 70 mm x 30 mm
WEIGHT (Meter Only)	200 gm

Conductivity/ TDS/ Temp. Meter

Model 3251 conductivity/TDS/Temp. Meter (without RS-232C)…………………………..$295.00
Model 3250 conductivity/TDS/Temp. Meter (with RS-232C)………………………………$395.00
Conductivity Cell, graphite, constant 1.0, with temp. 3ft cable……………………………$82.50
AC adaptor……………………………………………………………………………………$10.00

FEATURES

* AUTO/MANUAL RANGING
* AUTO-SWITCHING EXCITATION FREQ. FOR MAX. ACCURACY
* DISPLAYS SALINITY UP TO 80.0 ppt
* USER PROGRAMMABLE REF. TEMP. & TEMP. COEFFICIENT
* SELECTABLE 2-WIRE OR 4-WIRE CELLS FOR LONG CABLE LENGTH & WIDE MEASUREMENT RANGE
* RS-232C OUTPUT
* CE APPROVED
* SPLASH RESISTANT/WATERTIGHT CASE
* HIGHLY RELIABLE MECHANICAL TOUCH KEYS
* POWER DOWN MEMORY BACKUP
* BATTERY/AC ADAPTOR
* HIGH 50/60 Hz AC NOISE REJECTION



SALINITY DISPLAY

RANGE	RESOLUTION	ACCURACY
0.0 to 80.0 ppt	0.1 ppt	±1% FS

TEMPERATURE DISPLAY

RANGE	RESOLUTION	ACCURACY
-5.0 to 95.0 °C	0.1 °C	±0.2 °C

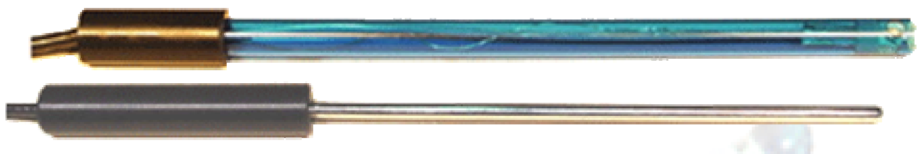
REFERENCE TEMP.	15.0 °C to 25.0 °C adjustable
TEMP. COEFFICIENT	0.0% to 4.0% adjustable
COMMUNICATION	RS-232C
TEMP. COMPENSATION	Yes
BATTERY LIFE	>10 Hours (Continuous Operation)
POWER SUPPLY	Batteries/Adaptor 6 AAA (alkaline)/115V or 230V AC
ATC PROBE	Thermistor (10K Ω at 25 °C)
AMBIENT TEMP.	0 to 50 °C
DISPLAY: Cond/Sal : Temp.	15 mm High: 8.7 mm High LCD
DIMENSIONS (L x W x H)	222 mm x 83 mm x 71 mm
WEIGHT	450 gm (Batteries Included)

CONDUCTIVITY DISPLAY

CELL CONSTANT	RANGE		RESOLUTION	ACCURACY
10 cm⁻¹	auto	0 to 999.9 µS/cm	0.1 µS/cm	±0.5% FS
	fixed	0 to 999.9 µS/cm		
	auto	1.000 to 9.999 mS/cm	0.001 mS/cm	±0.5% FS
	fixed	0 to 9.999 mS/cm		
	auto	10.00 to 99.99 mS/cm	0.01 mS/cm	±0.5% FS
	fixed	0 to 99.99 mS/cm		
	auto	100.0 to 300.0 mS/cm	0.1 mS/cm	±0.5% FS
	fixed	0 to 300.0 mS/cm		
1.0 cm⁻¹	auto	0 to 99.99 µS/cm	0.01 µS/cm	±0.5% FS
	fixed	0 to 99.99 µS/cm		
	auto	100.0 to 999.9 µS/cm	0.1 µS/cm	±0.5% FS
	fixed	0 to 999.9 µS/cm		
	auto	1.000 to 9.999 mS/cm	0.001 mS/cm	±0.5% FS
	fixed	0 to 9.999 mS/cm		
	auto	10.00 to 30.00 mS/cm	0.01 mS/cm	±0.5% FS
	fixed	0 to 30.00 mS/cm		
0.1 cm⁻¹	auto	0 to 9.999 µS/cm	0.001 µS/cm	±0.5% FS
	fixed	0 to 9.999 µS/cm		
	auto	10.0 to 99.99 µS/cm	0.01 µS/cm	±0.5% FS
	fixed	0 to 99.99 µS/cm		
	auto	100.0 to 999.9 µS/cm	0.1 µS/cm	±0.5% FS
	fixed	0 to 999.9 µS/cm		
	auto	1.000 to 3.000 mS/cm	0.001 mS/cm	±0.5% FS
	fixed	0 to 3.000 mS/cm		

Temperature Probes

Epoxy and Stainless Steel Body Temperature Probe



- Default connector for epoxy body probe is 8 pin connector (same configuration as Orion, 30K)
- Default connector for Stainless body probe is phone connector
- Other connectors are available, please specify when ordering
- Other temperature sensors are available, please specify when ordering
- 1 meter cable, other length of cable, please specify when ordering

Epoxy Body

Part #	Temp sensor	Price
TP-120	Pt 100	$79.00
TP-130	Pt 1000	$79.00
TP-170	10K	$68.00
TP-180	30K	$68.00

Stainless Body

Part #	Temp sensor	Price
TP-320	Pt 100	$59.00
TP-330	Pt 1000	$59.00
TP-370	10K	$48.00
TP-380	30K	$48.00

Part C. Industrial Process Electrodes

Inline/ submersible Electrodes

These industrial process electrodes can be configured to ORP and Ion-selective electrodes, please ask.

The common features of Inline/submersible pH electrodes

- ElectroJelly™ filled unless specified
- Ag/AgCl Reference
- Operating temperature: 100 °C for glass body electrode, 80 °C for epoxy body electrode
- Operating Pressure: 150 psi for glass body, 100 psi for epoxy body electrodes
- ½" (M) NPT thread
- Housing size: 4.5" x 1" (dia)
- The default length of electrode beyond housing is 1", but it can be manufactured according your requirement.
- 10 feet low noise cable with BNC connector, other length of cable and connectors are available, please specify when ordering

Part #	Housing Material	Electrode body	Junction	Price
WP-861-10B	CPVC	Glass	Double	$98.00
WP-863-10B	CPVC	Glass	Single	$75.00
WP-865-10B	PVC	Glass	Double	$95.00
WP-867-10B	PVC	Glass	Single	$72.00
WP-871-10B	CPVC	Epoxy	Double	$93.00
WP-873-10B	CPVC	Epoxy	Single	$70.00
WP-875-10B	PVC	Epoxy	Double	$90.00
WP-877-10B	PVC	Epoxy	Single	$67.00
12CAP	PVC storage cap for ½" NPT (M) electrode			$10.00

* Electrodes with ATC probe are available, please ask.

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WEISS™

Removable/Disposable Electrode and Housing

The removable/ disposable industrial pH glass body electrode is an Ag/AgCl double junction with ElectroJelly™ filled electrode. It keeps the constant reference potential and also protects against sample contamination. The electrode also has a metal cap which is interchangeable with PG 13.5 Euro-Cap and fits many different companies' electrode housings. This means the users can easily replace their un-functional PG 13.5 Euro-Cap electrodes for a small fraction of the cost.

Note: You are qualified for a free 10 feet long TNC to BNC cable when you order this replacement electrode.

The electrode housing is built either by PVC or CPVC material with double Viton® O-ring to seal the sample flow into the housing.

Part #	Item	Price
PH8087	Glass body, SJ pH electrode, 12 x115(L) mm excluding cap	$81.00
PH8088	Glass body, DJ pH electrode, 12 x115(L) mm excluding cap	$98.00
PVC-01	PVC Housing, ¾" NPT (M)	$35.00
CPVC-01	CPVC Housing, ¾" NPT (M)	$38.00
TB-10	TNC to BNC converter with 10 feet low noise cable	$22.00

Self-cleaning Flat with Grounding Electrodes

These self-cleaning flat pH electrodes can have many different configurations, but some common characteristic are listed below.

- Flat Glass, Double or Single Junction with ElectroJelly™ filled
- Large Ceramic Junction
- 10 feet cable
- Many different connectors to chose
- The electrode extends beyond the thread can be modify to your specification

Electrode selection

Weiss
Type of Material, P- PVC; C- CPVC; K-Kynar
Bulb Shape, F-Flat
Junction Type, 1- Single; 2- Double
Thread size (M) NPT, 12- 1/2"; 34- 3/4"; 10- 1.0"

W P F 2 34 0 0 15 - 6 B

Connector, B- BNC; N- None
Cable length (ft)
Electrode extend length from thread - 30- 3"; 20- 2"; 15- 1.5"; 10- 1"; 05 -0.5"
Solution Grounding, 0- No; 1- Yes
ATC, 0- No; 1- pt100; 2- pt1000; 3- 10K; 4- 30K; 5- other

Electrode Housing with Nut Lock

There are two types of electrode housing. Type I – without bulb guard is designed for epoxy body electrodes which already have their own guard and flat surface electrodes such as solid-state Ion-selective, flat surface pH, and ORP electrodes. Type II – with bulb guard is designed for glass body pH electrodes. Both housings contain Viton® O-ring to seal the sample flows in.

Type I Housing (without guard):

1. Housing Length – 3.5 inch (standard), other lengths are available please specify when ordering
2. Electrode extension from thread is 1" (standard). This length can be modified to your specification through adjusting either the housing or electrode length.

Part Number	Description	Price
EH1C1210	CPVC, ½" (M) NPT thread, 1" extension	$28.00
EH1P1210	PVC, ½" (M) NPT thread, 1" extension	$25.00
EH1C3410	CPVC, ¾" (M) NPT thread, 1" extension	$28.00
EH1P3410	PVC, ¾" (M) NPT thread, 1" extension	$25.00

* Last two digits mean extension length. You can make a change, for example, if the extension is 1.5", the part number should be EH1C1215.

Type II Housing:

1. Housing Length – 4.5 inch (standard), other lengths are available please specify when ordering
2. Electrode protection guard length (the same as electrode extension length) is 1" as a standard. This length can be modified to your specification through adjusting either the housing or electrode length.

Part Number	Description	Price
EH2C1210	CPVC, ½" (M) NPT thread, 1" extension	$38.00
EH2P1210	PVC, ½" (M) NPT thread, 1" extension	$35.00
EH2C3410	CPVC, ¾" (M) NPT thread, 1" extension	$38.00
EH2P3410	PVC, ¾" (M) NPT thread, 1" extension	$35.00

Electrode Selection:

With this electrode housing, it allows you to use lab type electrodes in industrial processing. But, one minor modification should be applied. To be allowed to use this electrode housing, the electrode cap has to be changed. The cap with these types of housing are called "Hat Cap". First select a lab type electrode (it should be a sealed type) you like and then add an "H" after the electrode part number. For example, epoxy body pH electrode, PHS-0101-3B should be changed to PHS-0101H-3B, ORP-1001-3B to ORP-1001H-3B, WCL1001(half-cell chloride electrode) to WCL1001H or RE6097 (Glass body, double Junction reference electrode) to RE6097H.

Part D. Calibration & Cleaning Solutions

WISECAL™ Calibration Solutions:

With WiseCal™ pH Buffer, Conductivity and ORP Standard solutions, you can benefit from:

- Easy-to-carry, No more containers to carry, great for field use. Unlike the pouch buffers, which are too difficult to handle - you have to tie up one hand and use the other hand to hold the buffer or constantly search for something to support the pouch to keep it standing up. **WiseCal**™ allows you free use of both of your hands to finish your job easily and effectively
- No containers are required! No more containers to clean.
- Easy-to-use and allows pH, conductivity & ORP electrodes to be directly calibrated in the bottle.
- Long-life stability, especially for basic pH buffers. No more worry about risk of contamination.
- Accurate, NIST traceable, very economical, no more wasted solutions from overfilling.

Just Switch to **WiseCal**™ pH Buffer from pouch buffer only, you can save more than $876* per year

* Assume the calibration twice a day and use two buffers. Pouch buffers cost about $1.00/each or more. One bottle WiseCal™ pH Buffer contains 500-ml solution and can be calibrated more than 25 times.

How do you use WiseCal™ Solutions?

1. Simply loosen the cap, black, from measuring chamber. Don't loosen and remove the cap from the filling mouth of the bottle, the white one, to prevent the solution being exposed to the air and getting contaminated.
2. Gently squeeze the bottle to fill measuring chamber with required amount of solution.
3. Remove cap, black, from measuring chamber.
4. Insert the electrode into measuring chamber to do the calibration.
5. After calibration, pour the solution in the measuring chamber out. Re-cap the measuring chamber with the black cap.

pH Buffers

All Weiss color coded pH buffers are designed for ready-to-use, immediate identification, ease of reseal and mold controlled for long term use. All pH buffers are made from high-purity deionized water and ACS reagent chemicals, and weigh chemicals to 4th decimal point. Each lot of these buffers is standardized against the buffer solutions traceable to the NIST standard reference materials. Values of these pH buffers are accurate ±0.01pH at 25 °C.

pH Buffers (regular bottle):

Catalog No.	Description	Volume	Price
WE-1103-1	pH buffer, pH 4.00 ± 0.01 @ 25 °C, Red	500 ml	$5.50
WE-1103-5	pH buffer, pH 4.00 ± 0.01 @ 25 °C, Red	1000 ml	$9.00
WE-1103-1G	pH buffer, pH 4.00 ± 0.01 @ 25 °C, Red	1 Gallon	$25.00
WE-1105-1	pH buffer, pH 7.00 ± 0.01 @ 25 °C, Yellow	500 ml	$5.50
WE-1105-5	pH buffer, pH 7.00 ± 0.01 @ 25 °C, Yellow	1000 ml	$9.00
WE-1105-1G	pH buffer, pH 7.00 ± 0.01 @ 25 °C, Yellow	1 Gallon	$25.00
WE-1108-1	pH buffer, pH 10.00 ± 0.01 @ 25 °C, Blue	500 ml	$5.50
WE-1108-5	pH buffer, pH 10.00 ± 0.01 @ 25 °C, Blue	1000 ml	$9.00
WE-1108-1G	pH buffer, pH 10.00 ± 0.01 @ 25 °C, Blue	1 Gallon	$25.00
WE-1110-K	pH buffer kit, contains three 500 ml-bottles each of pH 4, 7 and 10 buffers	3 x 500 ml	$15.50

WiseCal™ pH Buffers:

Catalog No.	Description	Volume	Price
WE-1103-2	pH buffer, pH 4.00 ± 0.01 @ 25 °C, Color Coded, Red	500 ml	$7.00
WE-1105-2	pH buffer, pH 7.00 ± 0.01 @ 25 °C, Color Coded, Yellow	500 ml	$7.00
WE-1108-2	pH buffer, pH 10.00 ± 0.01 @ 25 °C, Color Coded, Blue	500 ml	$7.00
WISECAL-K	pH buffer kit, contains three 500 ml-bottles each of pH 4, 7 and 10 buffers	3 x 500 ml	$19.50

pH and Reference Electrode Accessories

Catalog No.	Description	Volume	Price
WE-3157	pH Electrode REJUVENATOR, KF with sulfuric acid	100 ml	$8.00
WE-3160	4 M KCl Reference fill solution for double junction electrodes or soaking electrodes	500 ml	$8.00
WE-3161	pH electrode storage solution, pH 4.0 buffer (clear) with KCl	500 ml	$8.00
WE-3162	PROTEIN REMOVER 1% pepsin with pH 1.0	100 ml	$8.00
WE-3163	0.1 N HCl pH electrode cleaning solution	500 ml	$6.00
WE-3164	0.1 N NaOH pH electrode cleaning solution	500 ml	$6.00
WE-3165	4 M KCl with saturated AgCl Reference fill solution for single junction electrodes	100 ml	$8.00
WE-3167	3.5 M KCl with saturated AgCl Reference fill solution for single junction electrodes	100 ml	$8.00
WE-3170	10%(w/v) KNO3, Reference fill solution for double junction electrodes	100 ml	$8.00
WE-3192	Electrode storage bottle, one 30 ml-bottle with 1 O-ring for F10~12 mm electrodes	N/A	$3.50

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Conductivity Standards

Weiss conductivity calibration standards are made from ACS reagent grade potassium /sodium chloride and high-purity of deionized water. They may be used as a secondary standard solution for calibration of conductivity cells and conductance

Conductivity Calibration Standards:

Catalog No.	Description	Volume	Price
WE-3110	717.5 µS/cm at 25 °C	1 liter	$16.00
WE-3112	1015 µS/cm at 25 °C	1 liter	$16.00
WE-3115	1 412 µS/cm at 25 °C	1 liter	$16.00
WE-3120	2 765 µS/cm at 25 °C	1 liter	$16.00
WE-3125	6 667 µS/cm at 25 °C	1 liter	$16.00
WE-3130	12 890 µS/cm at 25 °C	1 liter	$16.00
WE-3135	24 800 µS/cm at 25 °C	1 liter	$16.00
WE-3140	58 670 µS/cm at 25 °C	1 liter	$16.00
WE-3145	111 900 µS/cm at 25 °C	1 liter	$16.00

WiseCal ™ Conductivity Calibration Standards:

Catalog No.	Description	Volume	Price
WE-3210	717.5 µS/cm at 25 °C	500 ml	$16.00
WE-3212	1015 µS/cm at 25 °C	500 ml	$16.00
WE-3215	1 412 µS/cm at 25 °C	500 ml	$16.00
WE-3220	2 765 µS/cm at 25 °C	500 ml	$16.00
WE-3225	6 667 µS/cm at 25 °C	500 ml	$16.00
WE-3230	12 890 µS/cm at 25 °C	500 ml	$16.00
WE-3235	24 800 µS/cm at 25 °C	500 ml	$16.00
WE-3240	58 670 µS/cm at 25 °C	500 ml	$16.00
WE-3245	111 900 µS/cm at 25 °C	500 ml	$16.00

Ion-Selective Electrode Calibration Solutions

We guarantee the solutions we offer here meet major electrode manufacturer's requirements and fit your routine production and/or research needs.

All ISE standards are made from high-purity deionized water and ACS reagent chemicals. The chemicals are dried in an oven according standard analytical procedures and weighed by analytical balance to 4th decimal point (0.1 mg), dissolved in a grade "A" flask.

Ion-Selective Electrode Calibration Standards

Catalog No.	Description	Volume	Price
WE-2801	Ammonia & Ammonium Standard, 1000 ppm as N	500 ml	$27.00
WE-2805	Bromide Standard, 1000 ppm as Br-	500 ml	$27.00
WE-2810	Calcium Standard, 1000 ppm as Ca^{2+}	500 ml	$27.00
WE-2815	Chloride Standard, 1000 ppm as Cl-	500 ml	$27.00
WE-2820	Copper Standard, 1000 ppm as Cu^{2+}	500 ml	$27.00
WE-2825	Fluoride Standard, 1000 ppm as F-	500 ml	$27.00
WE-2830	Iodide Standard, 1000 ppm as I-	500 ml	$27.00
WE-2835	Nitrate Standard, 1000 ppm as NO_{3-}	500 ml	$27.00
WE-2840	Potassium Standard, 1000 ppm as K+	500 ml	$27.00
WE-2845	Silver Standard, 1000 ppm as Ag+	500 ml	$40.00
WE-2850	Sodium Standard, 1000 ppm as Na+	500 ml	$27.00

Ion-Selective Electrode Fill Solutions

Catalog No.	Description	Volume	Price
WE-2701	0.1M NH4Cl, for ammonia, sodium electrodes	125 ml	$8.00
WE-2702	0.1M NaCl, for Double-Junction (DJ) ammonium, potassium electrodes	125 ml	$8.00
WE-2703	0.1M NaCl/AgCl, for Single-Junction (SJ) ammonium, potassium electrodes	125 ml	$8.00
WE-2704	10% KNO3, for DJ Br-, Cl-, I-, Ag+, Cd2+, Cu2+, Pb2+ electrodes	125 ml	$8.00
WE-2705	10% KNO3/AgCl, for SJ Br-, Cl-, I-, Ag+, Cd2+, Cu2+, Pb2+ electrodes	125 ml	$8.00
WE-2706	4M KCl, for DJ fluoride, calcium electrodes	125 ml	$8.00
WE-2707	4M KCl/AgCl, for SJ fluoride, calcium electrodes	125 ml	$8.00
WE-2708	0.04M (NH4)2SO4, for DJ nitrate electrode	125 ml	$8.00
WE-2709	0.1M (NH4)2SO4, for DJ nitrate electrode	125 ml	$8.00
WE-2710	0.1M (NH4)2SO4/AgCl, for SJ nitrate electrode	125 ml	$8.00
WE-2711	10% KNO3, for cyanide electrode	125 ml	$8.00
WE-2712	10% KNO3/AgCl, for cyanide electrode	125 ml	$8.00
WE-2713	Equitransferent for fluoride, cadmium electrodes	125 ml	$10.00

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Ion-Selective Electrode Solution (ISE) Kits

Electrode	Type of Junction	Catalog No.	Description	List Price
Ammonia		WE-2100	1000 ppm as N standard, 10 M NaOH ISA, 0.1 M NH4Cl fill solution	$55
Ammonium	Single	WE-2111	1000 ppm as N standard, 5 M NaCl ISA, 0.1 M NaCl with AgCl fill solution	$55
	Double	WE-2112	1000 ppm as N standard, 5 M NaCl ISA, 0.1 M NaCl fill solution	$55
Bromide	Single	WE-2121	1000 ppm as Br- standard, 5 M NaNO3 ISA, 10% KNO3 with AgCl fill solution	$55
	Double	WE-2122	1000 ppm as Br- standard, 5 M NaNO3 ISA, 10% KNO3 fill solution	$55
Calcium	Single	WE-2131	1000 ppm as Ca2+ standard, 4 M KCl ISA, 4 M KCl with AgCl fill solution	$55
	Double	WE-2132	1000 ppm as Ca2+ standard, 4 M KCl ISA, 4 M KCl fill solution	$55
Chloride	Single	WE-2141	1000 ppm as Cl- standard, 5 M NaNO3 ISA, 10% KNO3 with AgCl fill solution	$55
	Double	WE-2142	1000 ppm as Cl- standard, 5 M NaNO3 ISA, 10% KNO3 fill solution	$55
Cupper	Single	WE-2151	1000 ppm as Cu2+ standard, 5 M NaNO3 ISA, 10% KNO3 with AgCl fill solution	$55
	Double	WE-2152	1000 ppm as Cu2+ standard, 5 M NaNO3 ISA, 10% KNO3 fill solution	$55
Fluoride	Single	WE-2161	1000 ppm as F- standard, TISAB II (liter), 4 M KCl with AgCl fill solution	$55
	Double	WE-2162	1000 ppm as F- standard, TISAB II (liter), 4 M KCl fill solution	$55
Iodide	Single	WE-2171	1000 ppm as I- standard, 5 M NaNO3 ISA, 10% KNO3 with AgCl fill solution	$55
	Double	WE-2172	1000 ppm as I- standard, 5 M NaNO3 ISA, 10% KNO3 fill solution	$55
Nitrate	Single	WE-2181	1000 ppm as NO3- standard, 2 M (NH4)2SO4 ISA, 0.1 M (NH4)2SO4 with AgCl fill solution	$55
	Double	WE-2182	1000 ppm as NO3- standard, 2 M (NH4)2SO4 ISA, 0.1 M (NH4)2SO4 fill solution	$55
Potassium	Single	WE-2191	1000 ppm as K+ standard, 5 M NaCl ISA, 0.1 M NaCl with AgCl fill solution	$55
	Double	WE-2192	1000 ppm as K+ standard, 5 M NaCl ISA, 0.1 M NaCl fill solution	$55
Silver/sulfite	Single	WE-2201	1000 ppm as Ag+ standard, 5 M NaNO3 ISA, 10% KNO3 with AgCl fill solution	$60
	Double	WE-2202	1000 ppm as Ag+ standard, 5 M NaNO3 ISA, 10% KNO3 fill solution	$60
Sodium	Single	WE-2211	1000 ppm as Na+ standard, 4 M NH4OH/4 M NH4Cl ISA, 0.1 M NH4Cl with AgCl fill solution	$55
	Double	WE-2212	1000 ppm as Na+ standard, 4 M NH4OH/4 M NH4Cl ISA, 0.1 M NH4Cl fill solution	$55

Ionic Strength Adjuster (ISA) for Ion-Selective Electrodes

Catalog No.	Description	Volume	Price
WE-2500	10 M NaOH, for Ammonia, Cyanide ISE	500 ml	$23.50
WE-2505	5 M NaCl, for Ammonium, Potassium ISE	500 ml	$23.50
WE-2510	5 M NaNO3, for Br-, Cd2+, Cl-, Cu2+, I-, Silver/Sulfide ISE	500 ml	$23.50
WE-2515	4 M KCl, for Calcium ISE	500 ml	$23.50
WE-2520	2 M (HN)2SO4, for Fluoroborate, Nitrate, Perchlorate ISE	500 ml	$23.50
WE-2525	4 M NH4OH with 4 M NH4Cl, for Sodium ISE	500 ml	$23.50
WE-2530	Total Ionic Strength Adjustor Buffer II (TISAB II), for F- ISE	1 Gallon	$50.00

ORP Calibration Solutions

ORP Standard Solution (APHA)

Catalog No.	Description	Volume	Price
WE-3150	Light's solution, ferrous/ferric ammonium sulfate, +476 mV at 25 °C, Pt electrode vs. Ag/AgCl reference electrode in saturated KCl	500 ml	$18.00
WE-3150-1	**WiseCal**™ Light's solution, +476 mV at 25 °C.	500 ml	$20.00

ORP Check Solution

Catalog No.	Description	Volume	Price
ORP-kit	ORP electrode check solutions; 1 of each pH 4 & 7 buffer (500 ml) and 20 g quinhydrone	N/A	$35.00

Part E. Cable & Connectors

General information of Cable and Connectors

1. How to decipher the part number?

The part number of Weiss electrodes normally divided by two parts, some electrodes only have one part. The first part is the electrodes and the second part is Cable length and Connector. For example, PHS0101-3B, the first part, PHS0101, is one type of electrodes; the second part, -3B, means 3 feet cable and BNC connector. If you like to have longer cable, e.g., 10 feet, and a US standard connector, simply change the number and the letter from 3B to 10U. The letter "U" means US standard connector.

If it only has one part number, e.g., WCL1001, that means the electrodes are standard equipped, 3 feet cable and BNC connector. You can add, for example, 10U to the end of part number to alternate it, WCL1001-10U.

2. If no specific defined cable length or connector, that means it is equipped with 3 feet cable and BNC connector except reference electrodes which come with "PIN' connector as default.

3. Additional charge of **$0.50/foot** for RG174 low noise cable, for other types of cables the price may vary.

4. Additional charge **$2.50/each** for US Standard Connector.

5. Additional charge **$10.00/each for** S7 connector.

6. For other types of connectors, please contact us for availability and pricing.

Part F. Electrode Library

Reference Books for pH & Ion-Selective Electrode Measurement

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Explanation of Misleading Nernst Slope by Boltzmann Equation

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The common misuse in the literature of the terms Nernst slope, Nernst factor, and Nernst potential should be corrected. The membrane electrode potential is explained by the Boltzmann distribution equation. The slope of 59 mV per ionic unit is not unique to the Nernst equation. Both the Nernst equation and the Boltzmann distribution equation give the same 59-mV slope based on different mechanisms. The slope indicates only the change of $-\Delta G$ regardless of mechanisms. To avoid any misleading inference to the wrong equation mechanism, a person's name should not be used to denote a common lope. The factors affecting the slope, the electrode potential and it's measurements, the importance of potential mechanism, and the modified Boltzmann equation are presented.

INTRODUCTION

There have been widespread misconceptions about the application of the Nernst equation to explain the mechanism of pH glass electrodes and ion selective electrodes (ISE). The terms Nernst slope *(5, 12, 13).* Nernst factor *(5, 9, 15).* and Nernst potential (5) have been commonly misused in the literature. An electrode potential may he divided, at least, into two types of electrode potential. One is the cell potential consisting of two half-cells, cathode and anode, with redox reactions such as a Zn in a ZnCI2 solution; the other is the capacitance potential based on the adsorption of charges or ions on a dielectric or semiconductor such as a glass without redox reactions. Potential measurement may be divided into two types of potentiometry", namely, faradaic potentiometry and nonfaradaic potentiometry (1, 2). The former is based on a device consisting of two half cells with a salt bridge for the potential measurements and the latter is based on a device with a dielectric or semiconductor adsorbed with charged particles or ions against a reference electrode; a conducting wire instead of a salt bridge is commonly used. A salt bridge can also function as a conducting wire for electron transfers; however, a conducting-wire cannot substitute for the salt bridge for ion transfers (see fig. 1). The reasons for the misuse of the Nernst equation have been explained in the literature (1, *2).*

ELECTRODE POTENTIAL MECHANISM

The electrode mechanism based on the Nernst equation. redox reaction. is represented

$$E = E^\circ + 2.3\ RT/nF \log([Ox]/[Red]). \qquad (1)$$

The electrode mechanism based on the double and triple layers of a capacitor is shown in Fig. 2.

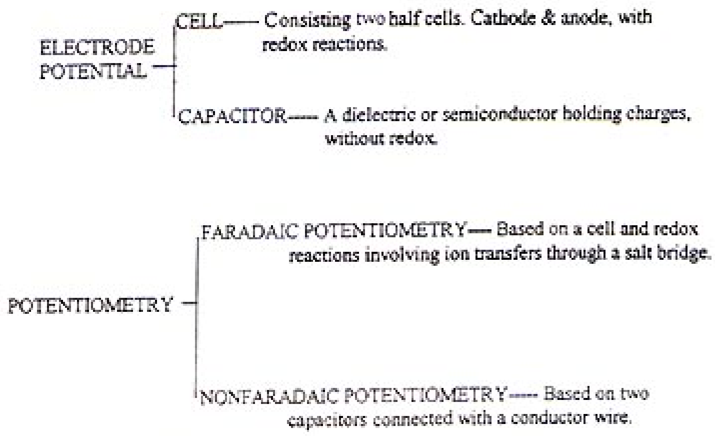

FIG. 1. Electrode potential and potentiometry.

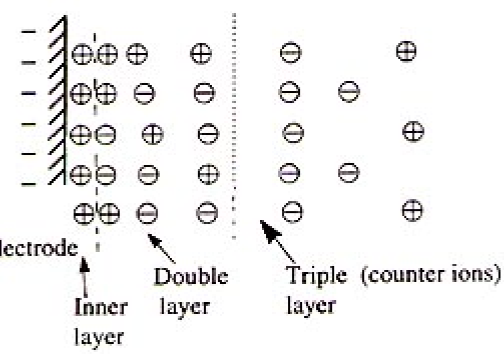

FIG. 2. Electric double and triple layers (not in proportion).

BOLTZMANN DISTRIBUTION EQUATION

The Boltzmann distribution equation can be written as follows:

$$N_i / N_0 = \exp\{(-Z_i eE) / kT\} \qquad (2)$$

The electrode potential is measured with respect to the bulk solution. The following quantities are found: $z_i = 1$ (for H^+); $e = 1.6 \times 10^{-19}$, electron charge; $k = 1.38 \times 10^{-23}$, Boltzmann constant: $T = 298$ at 25 ° C. The above equation will become

$$E = 2.3\, kT / \pm (z_i\, e \log(N_i / N_0)) = \pm\, 0.059 \log(N_i / N_0), \qquad (3)$$

where N_i is ions or charge particles on the electrode surface in charge density and No is ion concentration in bulk solution, Here

$$2.3\, RT / nF = 2.3\, z_i e / kT = 59 \text{ mV/pC} = -\Delta G. \qquad (4)$$

The adsorption of protons onto an insulator in an acidic solution with a Helmholtz double layer is described as the Helmholtz potential, which decreases about 60 mV per pH unit (3). In die electron transfer expressions, the expression exp(-(E_{tl} - E_F) / kT) based on the -Δ G change is called the Fermi function (3), All the slopes are 59 mV based on Δ G for different mechanisms. This causes some confusion. Now we can see why we should not denote a slope with a particular person's name for the same Δ G that is not unique to any mechanism. What is important is the mechanism, not the slope. It is clear that the slope does not explain the mechanism, We may suggest that the slope for the pH glass electrode and ISE be called the capacitance slope, as it is related to the capacitance potential (4).

MODIFIED BOLTZMANN EQUATION

In pH and ISE potential measurements, when both cations and anions are adsorbed at the same time onto an electrode surface, such as a pH glass electrode or an Ag_2S electrode (9), we call the capacitor a zwitterionic capacitor. The original Boltzmann equation is for an electrode with a single type of ion. Now for an electrode with a mixture of positive and negative charges, the Boltzmann equation may be modified as follows:

$$(\sum N_i^+ - \sum N_i^-)/(\sum N_0^\pm) = \exp(-z_i^+ z_i^- eE)/kT = \exp(-z_{iav}eE)/kT. \quad (5)$$

Then

$$E = K(\sum q_+ - \sum q_-)/C, \quad (6)$$

where q is charge density, C is capacitance, and K is a constant.

FACTORS AFFECTING THE SLOPE

In dealing with the pH glass electrode and ISE, the following factors are found to affect the electrode potentials:

1. Concentration;
2. Temperature;
3. Electrode surface conditions;
4. Number of charges of ions (8);
5. Stirring (6);
6. Suspension (7);
7. Zwitterionic nature, net charge density;
8. Anything changing ionic adsorption;
9. Isoelectric nature of surface material;
10. The Nernst equation deals only with concentration and temperature;
11. The Boltzmann equation covers most factors.

These factors affect the slope but do not change the mechanism. At pH 6-8, the pH glass electrode shows a nonlinear curve, not like what the Nernst equation predicts or what most people expect. The Nernst equation cannot he applied to most anions, such as OH^- , which plays a dominant role in the glass electrode potential development in basic media (11).

The resulting curve shown for Ag^+ by the Ag_2S electrode was actually for both the Ag^+ and the anion ligands. it was misleading by the Nernst equation and its slope (9).

The number 0.059 V for the Nernst slope has been quoted by most textbooks; however, a few textbooks quoted 0.0591, 0.05915 (12), 0.05916 (13), and 0.0591594 (16), possibly for better accuracy. The authors forgot the meaning of significant figures, As discussed previously, the slope is affected by many factors. To have more significant figures for the slope not only does not mean much, but also misleads to support the high accuracy of the reaction mechanism. This number with many decimals is just another calculation number (14).

MECHANISM AND THERMODYNAMICS

The mechanism is most important for understanding the electrode process and potential origin. The thermodynamics shows only the Δ G. the energy change, not the mechanism. In the textbooks of quantitative analysis and electroanalytical chemistry, the thermodynamics has been overemphasized, neglecting the mechanism. A correct mechanism should be based on careful experimental data. A slope does not affect the mechanism, but a mechanism sometimes affects the slope. It is improper to name a common slope after a particular person, suggesting incorrectly that the slope is unique for that mechanism and that when the calculated slope matches the experimental data, then the mechanism must be correct. This paper has proved that other equations also give the same 59-mV slope based on different mechanisms.

CONCLUSIONS

The Nernst equation has been misused in studies with membrane electrodes, including the pH glass electrode and ISE electrodes. There is no such thing as the Nernst slope, Nernst factor, or Nernst potential. First of all, the Nernst equation is not related to the capacitance potential. Second, a common slope, 59 mV, may be calculated from other equations from different mechanisms. It is also improper to name the slope the Nernst slope. the Boltzmann slope, or the Fermi slope, and the potential the Boltzmann potential, the Helmholtz potential, or the Nernst potential. The potential origin of membrane electrodes comes from the adsorption of charged ions or particles on the electrode surface, following the Boltzmann distribution, capacitance law. E = q /C. and Fruendlich isotherm. Contrary to what's shown in the Nernst equation, that the slope is infinitely linear, E = q/C is linear only in a limited range depending on the nature of ions, the electrode surface and thickness, etc. Here, the usefulness of a mechanism or theory depends on how good it can explain the electrode potential phenomena. If it cannot explain important facts, then it should either be revised or disposed of. It is a capital mistake to theorize before one has data. We have recently found that the IUPAC conventional redox mechanisms of calomel and Ag/AgC] reference electrodes have been erroneously postulated on the basis of the Nernst equation and Nernst slope (10). This is another example of the second Nernst hiatus (2).

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COUNTERION TRIPLE LAYER FOR EXPLAINING STIRRING AND TEMPERATURE EFFECTS ON pH MEASUREMENTS

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Abstract

This paper reports the pH glass electrode potential based on the double capacitor theory and a new, novel concept of mobile countertion triple layer next to the double layer to explain the electrode potential changes caused by stirring and temperature.

This mobile triple layer behaving like a rubber band may be removed by stirring or agitation and temperature and returned after stopping stirring or lowering temperature. Stirring and temperature affect differently the potential of the pH and SCE electrodes for their different mechanisms. Contrary to the past, results reported here were obtained from the experiments of glass electrode and SCE in two separate beakers connected with a conducting wire so that stirring one electrode while keeping the other unstirred. There is a weak charge attraction between the double and triple layers, not a strong covalent bonding for complexation so that the latter can be removed by stirring or temperature. In considering the present results and the new concept, the Boltzmann equation has been modified to include the net charge density and the triple layer potential. The counterion triple layer concept will have a tremendous impact on understanding the interface structure and properties and stimulate further studies and applications for ISE.

Introduction

Though the effects of stirring and temperature on the pH glass electrode potential have been known for a long time and discussed in literature (1), we have found conflicting recommendations on stirring in the pH measurements (4,5). Ineffective efforts for compensating the stirring and temperature effects have also been suggested because the past researchers did not understand their fundamental mechanisms. Although the double capacitor theory for the pH glass electrode potential has been proposed more than a decade ago, and ignored by most quantitative textbooks which still describe the redox and Nernst equation for the ion selective electrodes (ISE) (6,7) instead of the capacitor and the Boltzmann equation (6). Many electroanalytical chemists still believe the speculative redox reactions and mechanisms for the common reference electrodes, as a result, the stirring and temperature effects cannot be properly explained by the Nernst equation (7,8). This paper will demonstrate the important role of correct conception and mechanism for explanation of electrode phenomena. Hope this paper will stimulate electroanalytical chemists to be open-minded and encourage new challenges.

Experimental

A Corning pH/ion meter 150 was used for pH and potential measurements. A magnetic stirrer and Branson ultrasonic cleaner B-12, 50/60 Hz were used for agitation. In the study of stirring effect on pH glass electrode and SCE reference electrode, putting both electrodes in two separate beakers containing the same 50 mL solution. The two solutions were connected with an insulated conducting wire. For studying the stirring effect, one beaker was stirred while the other unstirred.

Results and discussion

Application of a pressure in an electrolyte solution gives rise to a potential difference and corresponding electric field. This is the phenomenon commonly called streaming potential (2,3) which has been applied to the stirring effect (2,3).

$$F = P\ (\ z\ /\ k(10^{-6}\ )\ ) \qquad (1)$$

where P is the pressure in mm Hg and (F is the zeta potential in mV. The streaming potential has been applied in the literature with a capillary mode and may not fit into the current non-capillary mode. It seems that the streaming potential equation cannot be applied to the commonly stirring effect on glass and SCE electrodes.

The double layer concept has been widely discussed, a new couonterion triple layer concept is suggested here as shown in Fig. 1. Except the adsorbed ions in the inner layer are not in the hydrated form, the ions in the double and triple layers are in the hydrated form (not shown in Fig. 1). This triple layer containing counterions is attracted to the double layer by the charge attraction force, not the covalent bonding complexation force. This is evidenced by its mobile characteristics. Its thickness is controlled by its counterion concentration, temperature, solvent, and other factors. Because of its characteristics, the present results suggest the presence of the counterion triple layer concept. It can explain the stirring and temperature effects on ISE and may be applied to other cases. The stirring effect results are shown in Figs. 2-6. As reported previously (6,7), as a capacitor, in an acidic solution the pH glass electrode is adsorbed with H^+ and in a basic solution it is adsorbed with OH^- showing a positive or negative potential, respectively (9). Its potential may be derived by the modified Boltzmann equation (10). In an unstirred solution, the electrode potential is

$$E_{unstirred} = E_i + E_d - E_{cit} \qquad (2)$$

where E_i, E_d and E_{cit} are inner layer potential, double layer potential, and counterion triple layer potential, respectively. In a stirred solution, the electrode potential will be

$$E_{stirred} = E_i + E_d \qquad (3)$$

Then

$$E_{cit} = E_{stirred} - E_{unstirred} \qquad (4)$$

Stirring actually enhances the electrode potential by removing the counterion triple layer effect. The difference between the stirred potential and the unstirred potential is the counterion triple layer potential which is illustrated in Figs. 2-5. In an acidic solution, the electrode is positively charged, at the interface, the counterion anions will compensate the electrode potential (or charge density) resulting in a less positive potential. In a basic solution, the electrode is negatively charged, at the interface, the counterion cations will compensate the electrode potential resulkting in a less negative potential, The stirrignand temperature effects as a function of pH are in a linear relationship as shown in Figs. 3- 4. When the solution pH went to more acid the stirred potential increased to more positive and pH went to more basic, the stirring potential moved to more negative. As shown in Fig. 5, the stirring effect is reasonably repeatable. At pH 10, the stirring effect showed somewhat unevenly. This might be due to somewhat different adsorption forms for H^+ and OH^- ions.

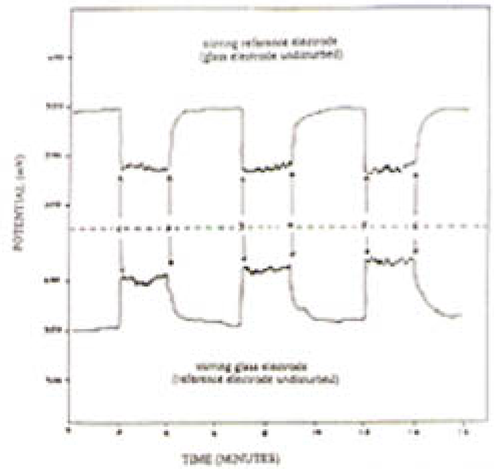

Figure 5a. Effect of ultrasonic stirring on potential of pH 1.0 solution (unbuffered)

1: ultrasonic stirring on
2,4,6: stirring off
3,5: ultrasonic stirring on again

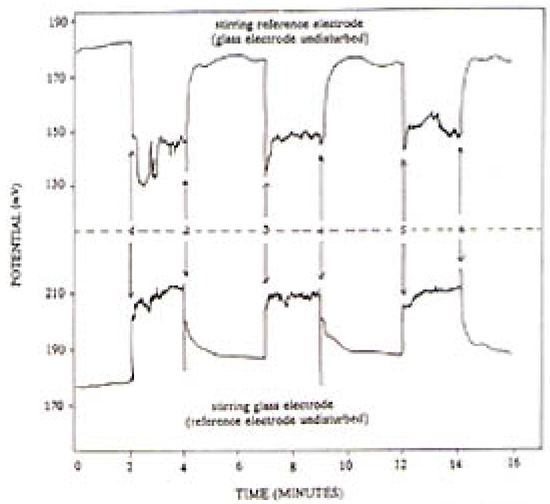

Figure 5b. Effect of ultrasonic stirring on potential of pH 4.0 solution (unbuffered, and added 1.0g NaCl)

1: ultrasonic stirring on
2,4,6: stirring off
3,5: ultrasonic stirring on again

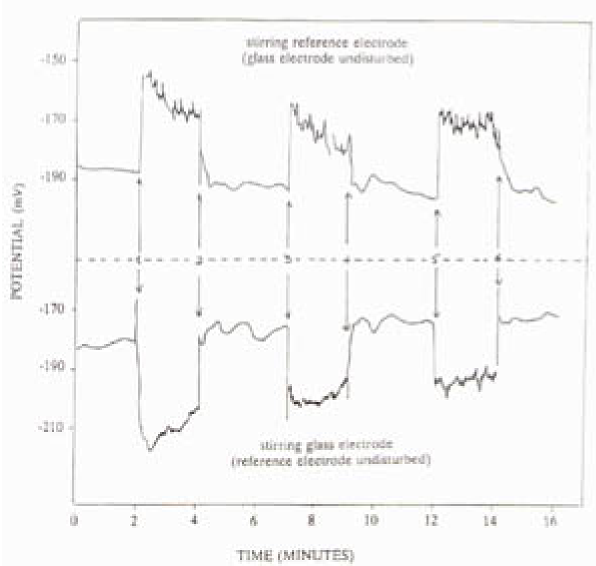

Figure 5c. Effect of ultrasonic stirring on potential of 10 solution (buffered)

1: ultrasonic stirring on
2,4,6: stirring off
3,5: ultrasonic stirring on again

A special attention should be made that in comparing the stirring effects of glass and SCE electrodes, they had an opposite effect (Fig. 4). The intersects for the two curves in Figs. 2 and 4 is not at pH 7, instead, at approximately pH 6.5. This is in agreement with the isoelectric point of glass at around 6.5 (7). In the literature it has been mistakenly assumed that the isoelectric point of pH glass is 7 (4, 12, 13). One must realize that the stirring effect on the two electrodes is not the same, having different directions. So it is difficulty to study and compensate the stirring effect for various pH values while the two electrodes are in the same solution or using the combination electrode. It was possible for us to study the stirring and temperature effects by putting the two electrodes in two separate beakers.

Results of the stirring and temperature effects on the glass electrode and SCE are shown in Fig. 3 indicating that stirring and temperature could remove the effect against the electrode potential providing that the reference electrode potential is kept constant.

The stirring effect on the SCE and glass electrode at different temperatures are quite different (Figs. 6a and 6b). The ultrasonic stirring of the SCE at pH 10 gave very unstable potentials (6b) because the Hg_2Cl_2 is relatively separated far away from the sample solution. The SCE is negatively charged due to adsorption of Cl-. The stirring would remove the counterion triple layer of cations, but also the part of KCl so that the SCE went to more positive. The junction potential at the tiny holes of the SCE might have had discontinuous changes of KCl concentration, non-equilibrium situation. The potential changed to more positive indicates the removal of chloride anions from the KCl solution at the junction. At higher temperatures the junction holes become larger making stirring easier to move away more chloride anions diluting the KCl concentration. So the resulting SCE potential became more positive and relatively stable. This also confirms that SCE behaves as a capacitor of Cl^- ISE, not a redox electrode. It is desirable to develop a stable reference electrode resisting environmental changes.

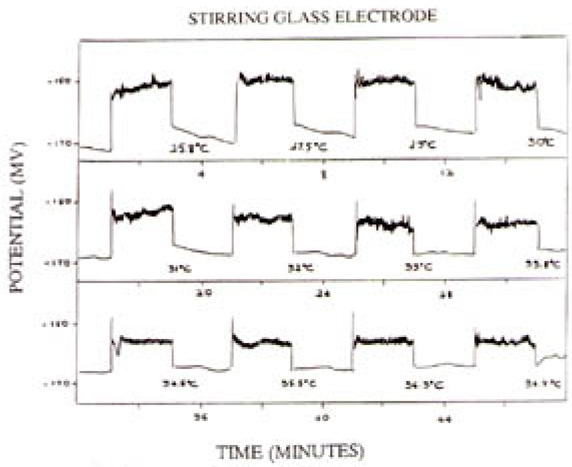

Figure 6a. Effect of temperature on potential of pH 10.0 solution

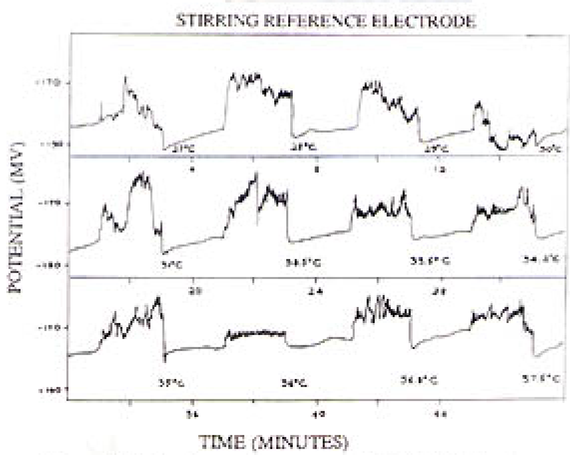

Figure 6b. Effect of temperature on potential of pH 10.0 solution

Both Nernst and Boltzmann equations do not explain the stirring and temperature effect mechanisms, they only show the temperature slope. The modified Boltzmann equation includes the net charge density (10). Now, in consideration of the presence of counterion triple layer, it may be further modified,

$$E_{unstirred} = 2.3\ kT/\ (Z \pm e)\ \log (N_i/N_o) - E_{cit} \qquad (5)$$

where Z ± is the net charge density for the zwitterionic electrode surface and E_{cit} is the counterion triple layer potential. One should remember that the Boltzmann equation only provides the electrode potential without considering the counterion triple layer effect which always exists in a practical, unstirred electrolytic solution. In other words, the potential calculated from the Boltzmann equation based on the electrode surface charge density is actually the potential of stirred solution without the counterion triple layer effect.

The counterion triple effect differs from other triple layer models. For instance, Hayes (11) described his model as surface complexation model (SCMS) that are used to describe the partition of inorganic metal ions between mineral and aqueous phases. These models are based on the premise that minerals have surface functional groups capable of forming complexes with ions in the interface region. Our triple layer model is mobile counterion phase with an opposite charges to the double layer, not related to metal ions for stable mineral complex formation.

Conclusion

A counterion triple layer concept has been proposed for explaining the stirring and temperature effects on pH glass electrode potential measurements which have not been adequately explained. It may also be applied to other cases. The pH glass and the SCE reference electrodes are considered as capacitors, their potentials are related to the capacitance potentials, $E = q/C$. This counterion triple layer is the one containing counterions next to the double layer and may be removed by stirring and temperature. It is mobile like a rubber band, returning to the original potential after stopping stirring or lowering the temperature. The Boltzmann equation has been modified to include the net charge and counterion triple layer effects. Removal of the triple layer enhances the electrode potential. Experiments using both glass electrode and SCE in two separate beakers made it possible to obtain the results reported here, because the two electrodes have different effects on potentials at different pH values The new concept seems to explain well the stirring and temperature effects on the pH measurements. Its applications to other cases are anticipated. Any concept, theory, or mechanism must be able to explain phenomena correctly, otherwise, they should be modified or discarded.

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