

Guide to Reliable pH, Ion and Conductivity Measurements



The MeterLab[®] Concept

Following Good Laboratory Practice is second nature with MeterLab

MeterLab from Radiometer Analytical incorporates all elements of the measuring chain - pH, ion and conductivity meters, electrodes and conductivity cells, solutions and sample handling - ensuring totally reliable measurements both in the laboratory and in the field. All elements are designed to make operation simple and error-free.



Radiometer Analytical offers a wide range of electrodes for every application and budget: combined pH, glass or reference electrodes featuring Red Rod or traditional technology, metal electrodes, ion-selective electrodes and conductivity cells. To choose the right pH electrode for your particular application, first refer to the table on pages 4 and 5.

For pH and conductivity measurements, Radiometer Analytical manufactures standards of the highest quality. Certain ranges are delivered with certificates of conformity and traceability to meet your accreditation and certification needs.

To keep your electrodes in excellent shape and extend their lifetime, Radiometer Analytical provides maintenance and filling solutions as well as necessary accessories.

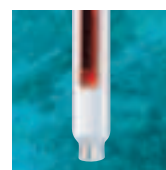
For more information on how Radiometer Analytical meters, sample stands and sample changers can help you ensure reliable pH, ion and conductivity measurements, please ask for our separate MeterLab brochure or visit us at www.radiometer-analytical.com.



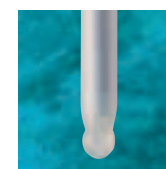
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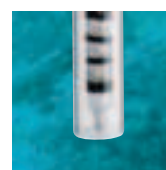
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Red Rod Electrodes

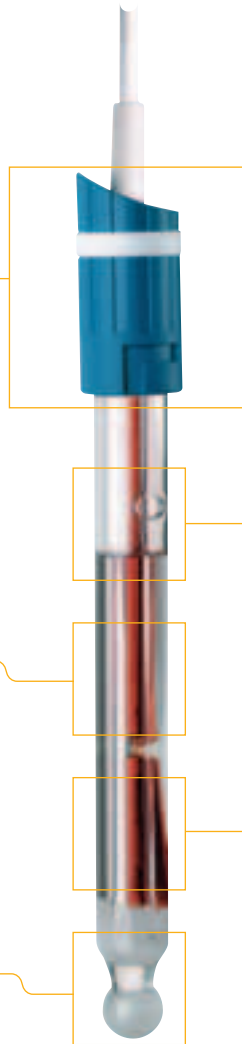
Radiometer Analytical's unique Red Rod Technology provides not only fast response time but also long-term accuracy and reproducibility.

Red Rod electrodes feature:

Reproducible measuring conditions ensured by the special bayonet head. The electrode fits into place in one easy movement and is fixed safely and securely in the same position for every measurement.

Wide temperature range (0 to 100°C) thanks to fast temperature response of Red Rod Technology.

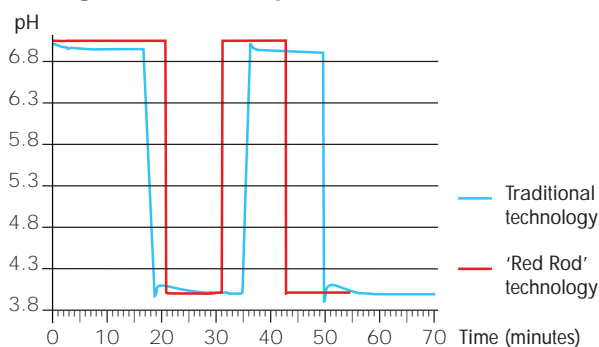
Trouble-free liquid junction as Red Rod encapsulation of reference elements means no silver ions and therefore less risk of clogging.



Fast and accurate response thanks to the symmetrical electrode chain formed by the internal and external Red Rod reference elements.

Stable signal as the Red Rod Technology protects the reference elements from light interference. Saturated KCl salt-bridge aids stable liquid junction potential.

Your guarantee of reproducible results



Red Rod combined pH electrode compared to traditional combined pH electrode

The symmetry of Red Rod electrodes means that the iso pH is the same as the zero pH which provides highly reproducible results even when temperature fluctuations occur.

The figure compares the measurements performed with a general-purpose Red Rod electrode and a traditional combined electrode. A MeterLab setup was used to measure certified standard pH solutions, pH 7.000 thermostated at 50°C and pH 4.005 thermostated at 25°C. The figure shows the fast response of the Red Rod electrode to changes in pH and temperature (curves offset to increase readability).

Combined pH Electrodes

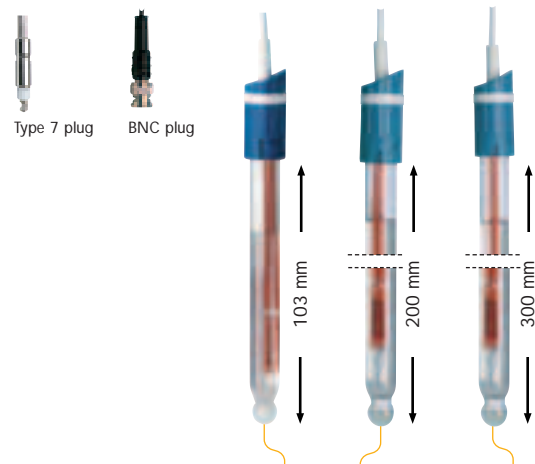
To meet your analysis needs, combined pH electrodes are available with a variety of lengths, diameters and reference systems. To discover the advantages of Red Rod reference systems, please refer to page 3.

All our electrodes are delivered with a Certificate of Conformity signed by the Total Quality Manager. This specifies the sensitivity, zero pH, response time and batch number of the electrode.

We supply a bottle of filling solution with every combined pH electrode (with the exception of the GK2401B and GK2401C).

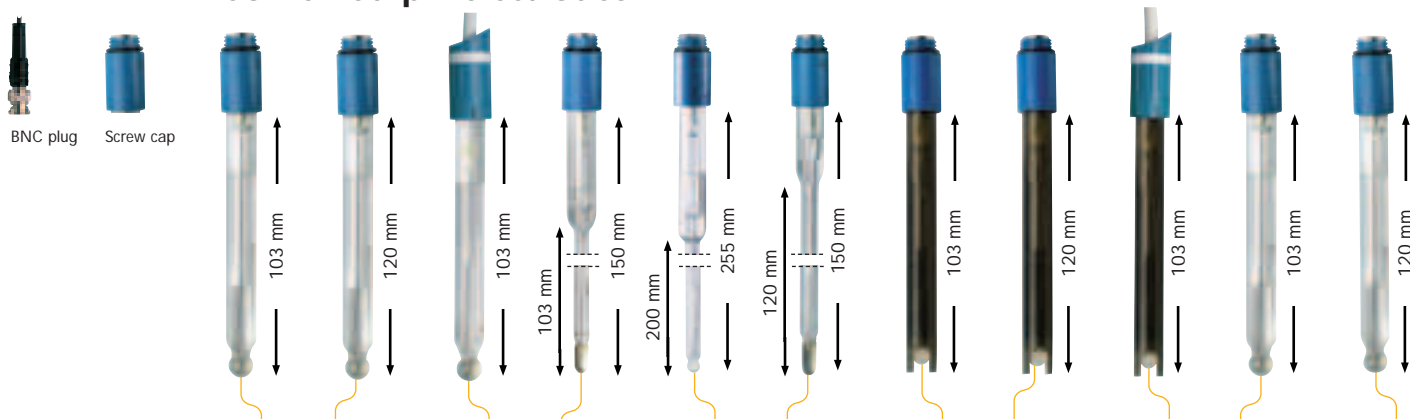
You may need a cable or plug adapter to connect your chosen electrode to your meter. Please see page 19.

Red Rod combined pH electrodes



Applications	General-purpose		
Type	pHC2001	pHC2002	pHC2003
Part no. Type 7			
Part no. BNC	E16M313	E16M315	E16M334
Reference system	Red Rod	Red Rod	Red Rod
pH range	0 – 12	0 – 12	0 – 12
Temperature range	-10 – 100°C	-10 – 100°C	-10 – 100°C
Diameter	12 mm	12 mm	12 mm
Minimum sample depth	18 mm	18 mm	18 mm
Liquid junction	Porous pin	Porous pin	Porous pin
Special features		Long	Long

Combined pH electrodes



Applications	General-purpose										Alkaline samples	
Type	pHC3001	XC100	pHC3081	pHC3006	pHC3006L	XC111	pHC3005	XC120	pHC3085	pHC3011	XC200	
Part no. BNC	E16M300		E16M305				E16M302		E16M342			
Part no. Screw cap	E16M301	B10C100		E16M306	E16M307	B10C111	E16M303	B10C120		E16M324	B10C200	
Reference system	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	
pH range	0 – 12	0 – 12	0 – 12	0 – 12	0 – 12	0 – 12	0 – 12	0 – 12	0 – 12	0 – 14	0 – 14	
Temperature range	0 – 80°C	0 – 80°C	0 – 80°C	0 – 80°C	0 – 80°C	0 – 80°C	0 – 80°C	0 – 80°C	-5 – 80°C	0 – 80°C	0 – 80°C	
Lower diameter	12 mm	12 mm	12 mm	6.5 mm	6.5 mm	8 mm	12 mm	12 mm	12 mm	12 mm	12 mm	
Minimum sample depth	18 mm	18 mm	18 mm	18 mm	14 mm	18 mm	12 mm	12 mm	14 mm	18 mm	18 mm	
Liquid junction	Porous pin	Porous pin	Porous pin	Porous pin	Porous pin	Porous pin	Porous pin	Porous pin	Porous pin	Porous pin	Porous pin	
Special features			Temp. sensor	Small Ø	Long, small Ø	Long, thin	Robust	Robust	Temp. sensor			

Obtaining accurate and reproducible results: some tips

✓ Remember to make regular calibrations to ascertain the actual sensitivity of the electrode. Ideal electrode sensitivity lies within the range 97 - 100%. However, the electrode may be used within as wide a range as 95 - 103%.

✓ The calibration buffers should have the same temperature as the sample. Under normal conditions, a deviation of $\pm 5^\circ\text{C}$ between sample and calibration buffers is acceptable.

✓ It is important to clean your electrodes regularly to ensure optimal response time. The GK ANNEX Electrode Maintenance Kit is ideal for electrodes with a saturated KCl salt-bridge. See page 18.



			Alkaline samples		Surface measurement	Soils	Cl ⁻ sensitive samples	Viscous samples	High KCl flow	Alkaline samples	General-purpose
pHC2401	pHC2005	pHC2085	pHC2011	pHC2015	pHC2441	pHC2051	pHC2501	pHC2601	pHC2701	GK2401B	GK2401C
E16M336	E16M337									945-261	945-252
E16M400	E16M500	E16M501	E16M317	E16M318	E16M320	E16M319	E16M321	E16M322	E16M323		
Red Rod	Red Rod	Red Rod	Red Rod	Red Rod	Red Rod	Red Rod	Red Rod	Red Rod	Red Rod	Red Rod	Red Rod
0 - 12	0 - 12	0 - 12	0 - 14	0 - 14	0 - 12	0 - 12	0 - 12	0 - 12	0 - 12	0 - 14	0 - 12
-10 - 100°C	-10 - 100°C	-10 - 100°C	0 - 100°C	0 - 100°C	-10 - 100°C	-10 - 100°C	-10 - 100°C	-10 - 100°C	-10 - 100°C	0 - 100°C	-10 - 100°C
12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	9.5 mm	9.5 mm
14 mm	14 mm	14 mm	18 mm	14 mm	flat	18 mm	18 mm	18 mm	14 mm	16 mm	16 mm
Annular ring	Porous pin Robust	Porous pin Temp. sensor	Porous pin	Porous pin Robust	Annular ring	Porous pin	Double/Porous	Sleeve	Annular ring	Porous pin	Porous pin

	Penetration	Microsamples		General-purpose Gel-filled			Penetration Gel-filled	General-purpose glass tubes			
	pHC3031	XC161	pHC3359	pHC3101	pHC3105	pHC3185	pHC3131	pHC4000	pHC4001	XC601	pHC4006
					E16M304	E16M329		E16M331			
B10C250	E16M325	B10C161	E16M330	E16M327	E16M308		E16M328	E16M332	B10C601	E16M333	
Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Calomel	Calomel	Calomel	Calomel
0 - 14	0 - 12	0 - 12	0 - 12	2 - 12	2 - 12	2 - 12	2 - 12	0 - 12	0 - 12	0 - 12	0 - 12
0 - 80°C	0 - 80°C	0 - 80°C	0 - 80°C	0 - 60°C	0 - 60°C	0 - 60°C	0 - 60°C	0 - 60°C	0 - 60°C	0 - 60°C	0 - 60°C
10 mm	8 mm	5 mm	2.5 mm	12 mm	12 mm	12 mm	8 mm	5 mm	12 mm	12 mm	6.5 mm
20 mm	14 mm	8 mm	2 mm	18 mm	18 mm	18 mm	14 mm	9 mm	18 mm	18 mm	14 mm
Porous pin	Porous pin	Porous pin	Fibre	Opening	Opening	Opening	Opening	Porous pin	Porous pin	Porous pin	Porous pin
Ground joint					Robust	Temp. sensor		Small Ø			Long, small Ø

✓ Never touch the electrode bulb with your fingers. Any grease may affect the electrode membrane and cause a drifting potential.

✓ The typical response time for a combined pH electrode is 20 s depending on the sample, sample temperature, stirring etc.

✓ The expected lifetime of a combined pH electrode is 1½ years provided that it has been correctly used and maintained.

Reference Electrodes

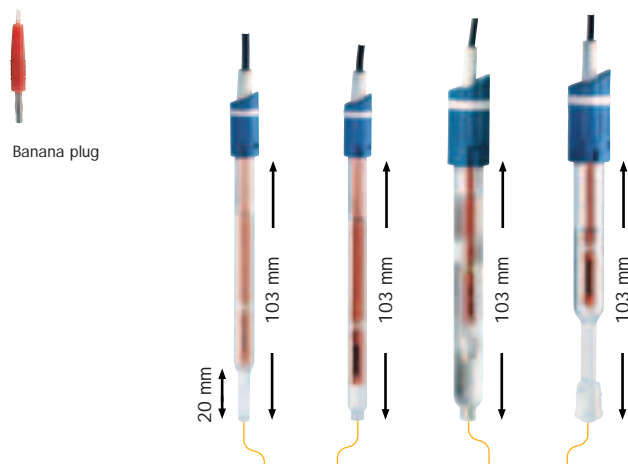
A reference electrode provides a stable potential whatever the measurement conditions. The main differences between reference electrodes are the type of reference system and the liquid junction.

Radiometer Analytical offers electrodes using both Red Rod and traditional technology (calomel, silver-silver chloride, mercurous sulphate and mercuric oxide).

Electrodes with a double junction are mostly designed for measurements using ion-selective electrodes or samples sensitive to Cl^- or K^+ .

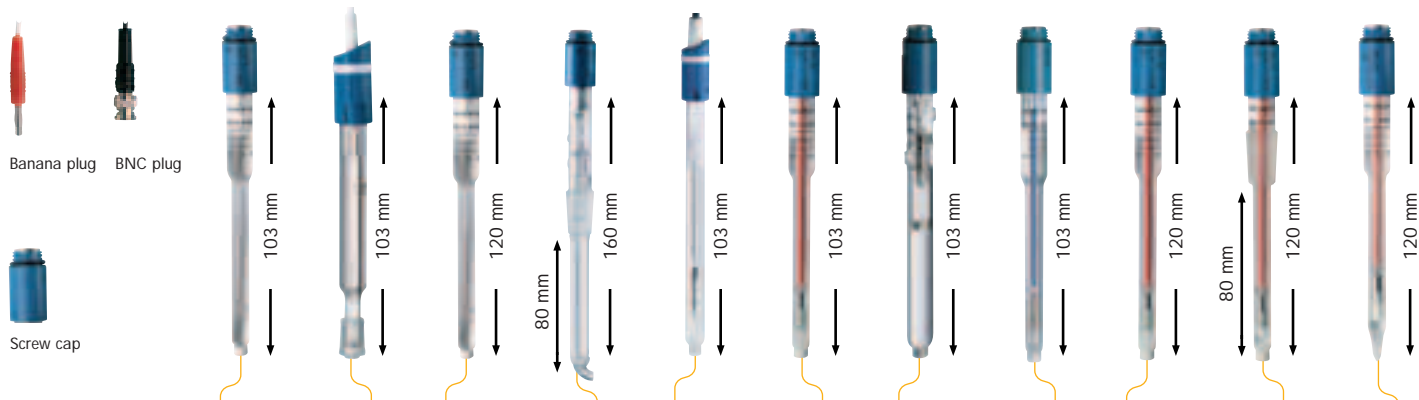
Sleeve junctions have a high flow to prevent the risk of clogging. Porous pins are used for general applications. Fibre reference electrodes have a slow flow to avoid contamination of the media.

Red Rod reference electrodes



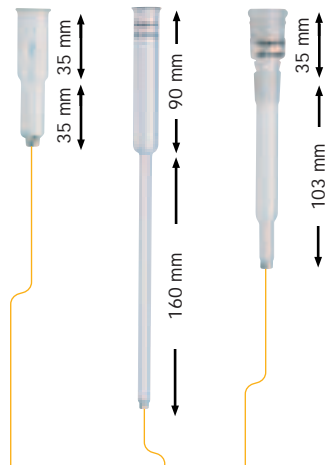
Applications	Micro-samples	General-purpose		Special-purpose
Reference system	Red Rod	Red Rod	Red Rod	Red Rod
Type	REF200	REF201	REF251	REF261
Part no.	E21M008	E21M009	E21M001	E21M010
Temperature range	-10 – 100°C	-10 – 100°C	-10 – 100°C	-10 – 100°C
Lower stem diameter	4 mm	7.5 mm	12 mm	12 mm
Liquid junction	Porous pin	Porous pin	Porous pin/ porous pin	Glass sleeve
Salt-bridge solution	Sat. KCl	Sat. KCl	Sat. KCl	Sat. KCl
Special features	For use with pHG200		Double junction	Sleeve

Reference electrodes



Applications	General-purpose	Non-aqueous media	Voltammetry	Impedance	Special-purpose			Non-aqueous media	Voltammetry		
Reference system	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Calomel	Calomel	Calomel	Calomel	Calomel	Calomel	Calomel
Type	REF321	REF361	XR300	XR820	REF401	REF421	REF451	REF921	XR100	XR110	XR130
Part no.	E21M002	E21M003	B20B300	B20C820	E21M011	E21M004	E21M005	E21M007	B20B100	B20B110	B20B130
Temperature range	-5 – 80°C	-5 – 80°C	-5 – 80°C	-5 – 80°C	-10 – 60°C	-10 – 60°C	-10 – 60°C	0 – 60°C	-10 – 60°C	-10 – 60°C	-10 – 60°C
Lower diameter	8 mm	12 mm	8 mm	8 mm	7.5 mm	8 mm	12 mm	8 mm	8 mm	8 mm	8 mm
Liquid junction	Porous pin	Glass sleeve	Porous pin	Porous pin/ fibre	Porous pin	Porous pin	Porous pin/ porous pin	Porous pin	Porous pin	Porous pin	Fibre
Salt-bridge solution	3 M KCl with sat. AgCl	3 M KCl with sat. AgCl	Sat. KCl + sat. AgCl	Sat. KCl + sat. AgCl upper res.	Sat. KCl	Sat. KCl	Sat. KCl in inner reservoir	1 M LiCl	Sat. KCl	Sat. KCl	Sat. KCl
Connection	Screw cap	BNC plug shielded cable	Screw cap	Screw cap	Banana plug	Screw cap	Screw cap	Screw cap	Screw cap	Screw cap	Screw cap

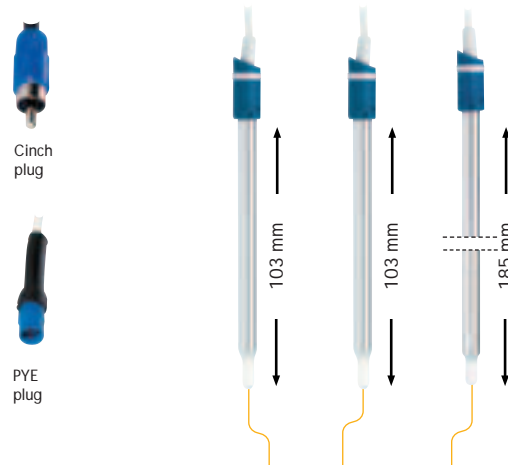
Salt-bridge junctions



Type	AL100	AL110	AL120
Part no.	B40A520	B40A550	B40A610
Lower diameter	12 mm	8 mm	8 mm
Junction	Ceramic	Ceramic	Ceramic
Special features	for Ø 7.5 or 8 mm ref. electrodes		for ref. electrodes with ground joint

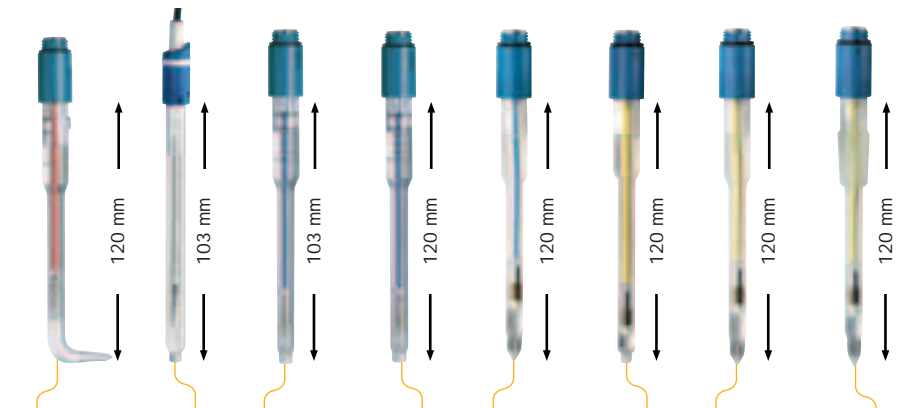
During measurement, the salt-bridge junction (also called liquid junction protection tube) prevents the reference electrode from being contaminated by the media and vice-versa. It consists of a glass tube terminated by a liquid junction. Always ensure the filling solution used corresponds to the application.

Temperature sensors



Type	T101	T201	T202
Part no.	E51M003	E51M001	E51M002
Temperature range	-10 – 105°C	-10 – 105°C	-10 – 105°C
Diameter	7.5 mm	7.5 mm	7.5 mm
Material	Glass	Glass	Glass
Connection	PYE	Cinch	Cinch
Instrument	PHM83/85 ION83/85 CDM83	PHM2XX CDM2XX PHM9X	PHM2XX CDM2XX PHM9X

For pH measurements and measurements with ion-selective electrodes and conductivity cells, use of a temperature sensor is recommended because temperature affects the results.



Chloride free			Voltammetry				
Calomel	Hg/Hg ₂ SO ₄	Hg/Hg ₂ SO ₄	Hg/Hg ₂ SO ₄	Hg/Hg ₂ SO ₄	Hg/HgO	Hg/HgO	Hg/HgO
XR150	REF601	REF621	XR200	XR230	XR400	XR430	XR440
B20B150	E21M012	E21M006	B20B200	B20B230	B20B400	B20B430	B20B440
-10 – 60°C	0 – 60°C	0 – 60°C	0 – 60°C	0 – 60°C	0 – 60°C	0 – 60°C	0 – 60°C
8 mm	7.5 mm	8 mm	8 mm	8 mm	8 mm	8 mm	8 mm
Fibre	Porous pin	Porous pin	Porous pin	Fibre	Porous pin	Fibre	Fibre
Sat. KCl	Sat. K ₂ SO ₄	Sat. K ₂ SO ₄	Sat. K ₂ SO ₄	Sat. K ₂ SO ₄	0.1 M KOH	0.1 M KOH	0.1 M KOH
Screw cap	Banana plug	Screw cap	Screw cap	Screw cap	Screw cap	Screw cap	Screw cap

Obtaining accurate and reproducible results: some tips

- ✓ To ensure a stable reference potential, the salt-bridge solution should not be more than 5 mm below the electrode filling hole. Top up when required.
- ✓ Always read the proper storage conditions described in the operating instructions.
- ✓ Clean your electrodes regularly. The operating instructions give details of the most suitable cleaning procedure. A correctly maintained reference electrode has a lifetime of approximately 2 years.

Glass pH Electrodes

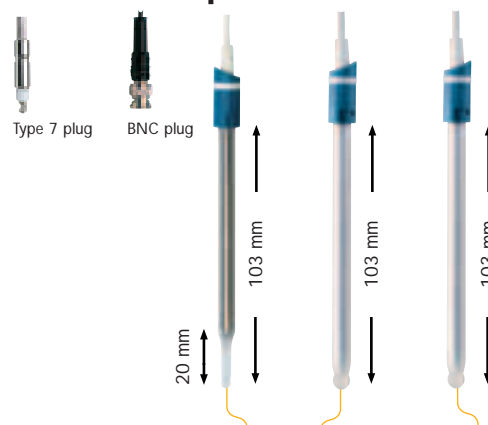
pH glass electrodes from Radiometer Analytical are made with highly shock-resistant glass, making them extremely tough. The average lifetime of a correctly maintained glass pH electrode is approximately 2 years.

Certain electrodes are made with special glass for pH measurements in strongly alkaline solutions. These electrodes allow measurements within the 0 - 14 pH range without significant deviation from the theoretical response.

Glass pH electrodes are always used in combination with reference electrodes. To find the right reference electrode for your application, refer to pages 8 and 9.

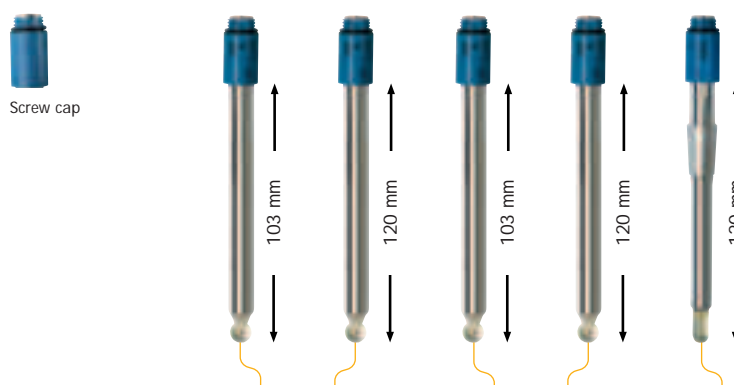
The zero pH of Red Rod glass pH electrodes when used with their recommended reference electrode is approximately pH 6.65. The zero pH of glass pH electrodes is approximately pH 6.65 when measured against a calomel reference electrode (e.g. REF421, XR100, XR110) and approximately pH 7.25 when measured against an Ag/AgCl reference electrode (e.g. REF321, XR300).

Red Rod glass pH electrodes



Applications	Micro-samples pHG200	General-purpose pHG201	Alkaline samples pHG211
Type			
Part no. Type 7		E11M005	
Part no. BNC	E11M002	E11M006	E11M003
pH range	0 - 12	0 - 12	0 - 14
Temperature range	10 - 100°C	-10 - 100°C	10 - 100°C
Lower diameter	4 mm	7.5 mm	7.5 mm
Reference system	Red Rod	Red Rod	Red Rod
Minimum sample depth	4 mm	7 mm	7 mm
Recommended reference electrode	REF200	REF201/251/261 REF201 for general use	

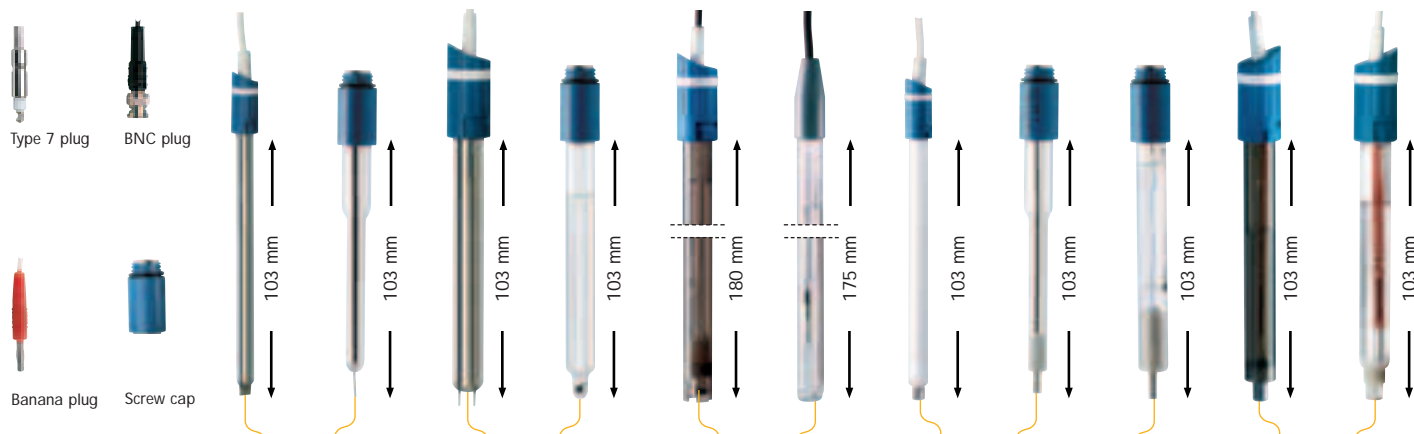
Glass pH electrodes



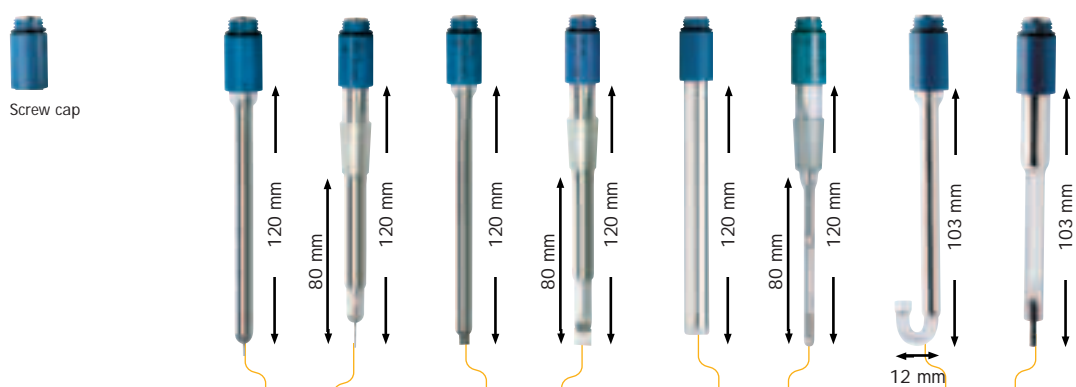
Applications	General-purpose		Alkaline samples		
	pHG301	XG100	pHG311	XG200	XG250
Part no.	E11M001	B10B100	E11M004	B10B200	B10B250
pH range	0 - 12	0 - 12	0 - 14	0 - 14	0 - 14
Temperature range	0 - 80°C	0 - 80°C	0 - 80°C	0 - 80°C	0 - 80°C
Diameter	12 mm	12 mm	12 mm	12 mm	12 mm
Reference system	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl	Ag/AgCl
Minimum sample depth	12 mm	12 mm	12 mm	12 mm	16 mm
Recommended reference electrodes	REF421 REF321	XR100 XR300	REF421 REF321	XR100 XR300	XR110

Metal and Combined Metal Electrodes

Single and combined metal electrodes can be used for redox measurements, redox titrations or potentiometric techniques whereas double metal electrodes are ideal for imposed current potentiometric titration. Radiometer Analytical's electrode range features single, double and combined metal electrodes with platinum, silver, gold, antimony, mercury and glassy carbon sensing elements.



Applications	General-purpose		Karl Fischer titrations	Redox meas.	Kappa no. titrations	COD titrations	Silver halides Titration			pH meas. titration	Redox meas.
Type	M241Pt	M231Pt	M231Pt2	MC3051Pt	MC408Pt	MC602Pt	M295Ag	M291Ag	MC6091Ag	MC2095Sb	MC241Au
Part no.	E31M001	E31M002	E32M001	E31M003	945-390	945-360	E34M003	E34M002	E34M004	E36M001	945-472
Sensing element	Platinum plate	Platinum wire	2 platinum wires	Platinum ring	Platinum ring	Platinum wire	Silver rod	Silver rod	Silver rod	Antimony rod	Gold disc
Temperature range	-10 – 100°C	-10 – 100°C	-10 – 100°C	0 – 80°C	-10 – 60°C	0 – 60°C	-10 – 100°C	0 – 80°C	0 – 60°C	-10 – 100°C	-10 – 100°C
Lower diameter	7.5 mm	8 mm	12 mm	12 mm	12 mm	9.5 mm	7.5 mm	8 mm	12 mm	12 mm	12 mm
Reference system				Ag/AgCl	Hg/Hg ₂ Cl ₂	Hg/Hg ₂ SO ₄			Hg/Hg ₂ SO ₄	Red Rod	Red Rod
Liquid junction				Porous pin	Porous pin	Porous pin			Porous pin	Porous pin	Annular ring
Salt-bridge solution				3 M KCl + sat. AgCl	Sat. KCl	Sat. K ₂ SO ₄			Sat. K ₂ SO ₄	Sat. KCl	Sat. KCl
Connection	Banana plug	Screw cap	2 x banana	Screw cap	Type 7 plug	Type 7 plug	Banana plug	Screw cap	Screw cap	BNC plug	Type 7 plug



Applications	Voltammetry					Micro samples	Electro-chemistry	Voltammetry Redox
Type	XM100	XM110	XM120	XM140	XM150	MEPT10MI/R	M221Hg	M291C
Part no.	B35M100	B35M110	B35M120	B35M140	B35M150	B35A978	E36M002	E36M003
Sensing element	Platinum wire Ø 1 mm	Platinum wire Ø 1 mm	Platinum plate 5 x 5 mm	Platinum plate 8 x 8 mm	Platinum disc Ø 10 mm	Platinum disc Ø 10 µm	Mercury cup	Glassy carbon rod Ø 3 mm
Temperature range	-10 – 100°C	-10 – 100°C	-10 – 100°C	-10 – 100°C	-10 – 100°C	-10 – 100°C	-10 – 100°C	0 – 60°C
Diameter	8 mm	10 mm	8 mm	10 mm	12 mm	4 mm	8 mm	8 mm
Connection	Screw cap	Screw cap	Screw cap	Screw cap	Screw cap	Screw cap	Screw cap	Screw cap

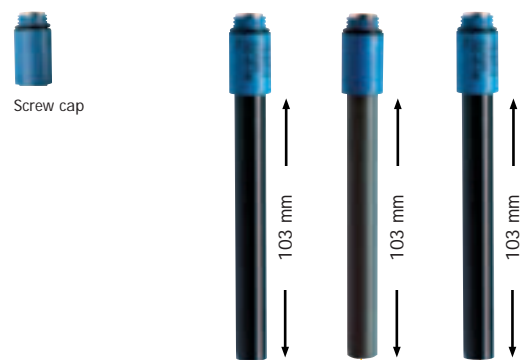
Ion-selective Electrodes

The use of ion-selective electrodes constitutes a quick and cost-effective method of determining ionic activity.

Due to their quality and diversity, Radiometer Analytical ion-selective electrodes efficiently solve various analytical problems of species in solution.

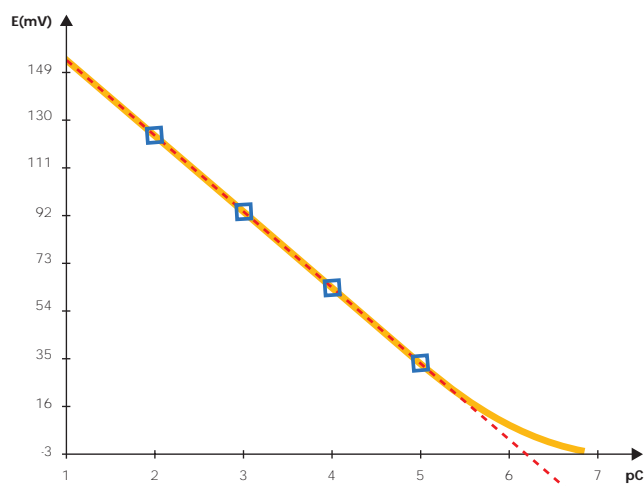
For details of the reference electrodes recommended for use with ion-selective electrodes, please see pages 8 and 9.

Each electrode is carefully checked before packing and is delivered with an individual control report including information such as the response curve, checkpoint value and slope.



Ion Species	Br ⁻	Ca ⁺⁺	Cl ⁻
Type	ISE25Br	ISE25Ca	ISE25Cl
Part no.	E41M001	E41M002	E41M003
Concentration range (M)	10 ⁻⁶ – 10 ⁰	2 x 10 ⁻⁶ – 10 ⁰	5 x 10 ⁻⁵ – 10 ⁰
Concentration range (ppm)	0.08 – 80000	0.1 – 40000	1.8 – 35000
Temperature range	0 – 60°C	0 – 50°C	0 – 60°C
Diameter	12 mm	12 mm	12 mm
pH range	2 – 14	4 – 12	2 – 14
Sensor type	Solid-state	PVC membrane	Solid-state
Interfering ions	I ⁻ , S ²⁻ , CN ⁻ , SCN ⁻	Zn ⁺⁺ , Pb ⁺⁺	I ⁻ , CN ⁻ , Br ⁻ , SCN ⁻
Recommended reference electrodes	REF251	REF201/REF251 REF451	REF251 REF451 REF601

Analysis with ion-selective electrodes is reliable and convenient when a few simple guidelines are followed:



Typical calibration curve for an ion-selective electrode.

✓ Ion-selective electrodes respond logarithmically over several decades of concentration. However, to be able to rely on the result in the area near the detection limit, you must use several calibration points - see figure.

✓ Low calibration solutions should be prepared each time the electrode is calibrated.

✓ Always calibrate the lowest standard concentration first.

✓ Make sure that calibration standards and samples have the same pH value, temperature and ionic strength. If necessary, add ionic strength adjustment buffer (TISAB/ISA solutions).

✓ Some ion-selective electrodes are sensitive to light so use black beakers (part no. 904-515) when measuring Cl⁻, I⁻ and Br⁻.



Cl ⁻	CN ⁻	Cu ⁺⁺	F ⁻	F ⁻	I ⁻	K ⁺	Na ⁺	NH ₄ ⁺	NO ₃ ⁻	Pb ⁺⁺	S ⁻ (Ag ⁺) ⁺
ISE/HS25Cl	ISE25CN	ISE25Cu	ISE25F	ISEC301F	ISE25I	ISE25K	ISE21Na	ISE25NH4	ISE25NO3	ISE25Pb	ISE25S
E41M004	E41M005	E41M006	E41M007	E41M017	E41M008	E41M009	E41M010	E41M013	E41M014	E41M015	E41M016
10 ⁻⁶ – 10 ⁰	5 x 10 ⁻⁷ – 10 ⁻³	10 ⁻⁶ – 10 ⁰	5 x 10 ⁻⁷ – 10 ⁰	5 x 10 ⁻⁷ – 10 ⁰	10 ⁻⁶ – 10 ⁻¹	2 x 10 ⁻⁶ – 10 ⁰	2 x 10 ⁻⁶ – 10 ⁰	3 x 10 ⁻⁶ – 10 ⁰	3 x 10 ⁻⁶ – 10 ⁰	10 ⁻⁶ – 10 ⁰	5 x 10 ⁻⁷ – 10 ⁰
0.04 – 35000	0.013 – 25	0.06 – 60000	0.01 – 20000	0.01 – 20000	0.13 – 13000	0.08 – 40000	0.04 – 20000	0.06 – 20000	0.2 – 60000	0.2 – 200000	0.02 – 30000
0 – 60°C	0 – 60°C	0 – 60°C	0 – 60°C	0 – 50°C	0 – 60°C	0 – 50°C	0 – 70°C	0 – 50°C	0 – 50°C	0 – 60°C	0 – 60°C
12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	12 mm
2 – 4	9 – 14	0 – 14 (3-7 direct meas.)	5-11 (10 ⁻¹ M F) 5-7 (10 ⁻⁶ M F)	5-7 (10 ⁻⁶ M F)	2 – 12	2 – 12	5 – 12	3 – 8	3 – 10	3 – 7 (direct meas.)	11 – 14 (direct meas.)
Solid-state	Solid-state	Solid-state	Solid-state	Solid-state	Solid-state	PVC membrane	Glass	PVC membrane	PVC membrane	Solid-state	Solid-state
I ⁻ , CN ⁻ , Br ⁻ , SCN ⁻	I ⁻ , Br ⁻ , S ²⁻	HgS, Ag ⁺ , Cl ⁻	OH ⁻	OH ⁻	CN ⁻ , Hg ⁺⁺ Br ⁻ , SCN ⁻	NH ₄ ⁺ , Rb ⁺	Li ⁺ , NH ₄ ⁺ Rb ⁺ , Ag ⁺	K ⁺	Cl ⁻ , Br ⁻ , NO ₂ ⁻	Hg ⁺⁺ , Cu ⁺⁺ Ag ⁺	Precipitated cations forming complexes with sulphides
REF251 REF451 REF601	REF201/REF251 REF451	REF201/REF251 REF451	REF201/REF251 REF451	Built-in Ag/AgCl reference	REF201/REF251 REF451	REF251 REF451	REF251 REF451	REF251 REF451	REF201/REF251 REF451	REF251 REF451	REF251 REF451

REF251 and REF451 are double-junction electrodes. You may need to change the filling solution in the second compartment for certain measurements (see operating instructions).

* Equally sensitive to Ag⁺.

Electrode membranes



Calcium



Sodium



Cyanide



Fluoride

The sensing element of an ion-selective electrode is the membrane. The type of membrane varies depending on the species to be measured. Membranes may be solid-state (e.g. cyanide or fluoride), PVC (e.g. calcium) or glass (sodium).

Accessories for PVC membrane electrodes

Ion & Electrode	Membrane kit part no.	Inner solution part no.
Ca ⁺⁺ , ISE25Ca	E91M001	S41M001
K ⁺ , ISE25K	E91M002	S41M002
NH ₄ ⁺ , ISE25NH4	E91M003	S41M003
NO ₃ ⁻ , ISE25NO3	E91M004	S41M004

The membrane kit contains three electrode tubes and a bottle of inner solution.

The electrode insert can be ordered separately:

- M27Ag-9 (part no. E34M001).

Electrode insert with screw cap.

Conductivity Cells

It is important to choose a cell with the right construction and geometry for your particular application and working conditions.

Radiometer Analytical offers conductivity cells for a wide variety of applications.

2-pole cells have a traditional design based on two plates of platinum. They are ideal for routine measurement of conductivity and for use with a sample changer due to the easy rinsing.

3-pole cells consist of 3 platinum rings which facilitate optimal shielding during measurement.

4-pole cells consist of 4 platinum rings. They ensure accurate results over several decades of conductivity with a single cell using just one calibration. They are particularly recommended when performing high conductivity measurements.

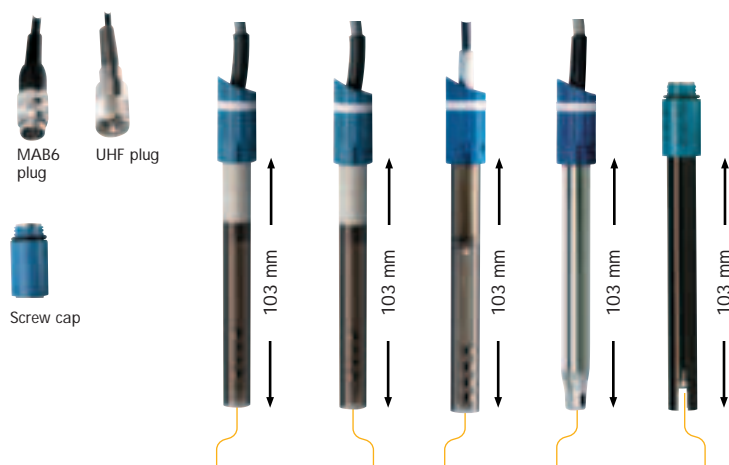
With a 4-pole cell, an alternating current is applied to the two outer rings and the voltage is measured on the 2 inner rings thereby avoiding errors due to polarisation effects and guaranteeing measurement accuracy. The CDC566T and CDC866T Conductivity Cells offer the advantages of this 4-pole design with a built-in temperature sensor. The tough epoxy body can be easily removed for rinsing which makes these cells ideal for measurements across a wide conductivity range even in harsh conditions.

Some tips

✓ Conductivity measurement is temperature dependent (if the temperature increases so does the conductivity value). When performing conductivity measurements, it is advisable to choose a cell with a built-in temperature sensor or use a separate sensor.

✓ Remember to calibrate your conductivity cell regularly as the cell constant may vary due to changes in electrode surface due to contamination, for example.

✓ If your cell is to be used with one of the conductivity meters in our current range, the user-friendly CDM210 or the high-performance CDM230, order a cell with a MAB6 plug. This plug type is also suitable for the CDM92 Conductivity Meter. For older meters (CDM80 or CDM83), choose a cell with a UHF plug.



Applications	General-purpose				
Type	CDC566T	CDC866T	CDC565	CDC641T	CDC745-9
Part no. UHF					
Part no. MAB6	E61M010	E61M015	E61M003	B15B001	
Part no. screw cap					E61M013
Body	Epoxy ¹⁾	Epoxy ¹⁾	Epoxy	Glass	Epoxy
Cell. constant (cm ⁻¹) ⁹⁾	1.0	1.0	1.0	0.85	1.0
Number of poles	4	4	4	2	2
Platinised	NO	YES	NO	YES	YES
Temperature sensor	YES	YES	NO	YES	NO
Diameter	12 mm	12 mm	12 mm	12 mm	12 mm
Max. temperature	80°C	80°C	80°C	100°C	100°C
Min. immersion depth	35 mm	35 mm	30 mm	14 mm	14 mm
CDM210/CDM230	YES	YES	YES	YES	YES ⁹⁾
CDM92	YES	YES	YES	YES	YES ⁹⁾
CDM80	NO	NO	NO	NO	NO
CDM83	NO	NO	NO	YES ⁹⁾	YES ⁹⁾

1) Removable epoxy tube for easy rinsing (can be replaced by glass tube - see accessories)

2) Use adapter part no. A94P002

3) Use cable part no. A94L136

4) Use cable part no. A94L119

5) Polymethylpentene. Removable part for easy rinsing

6) Minimum sample volume

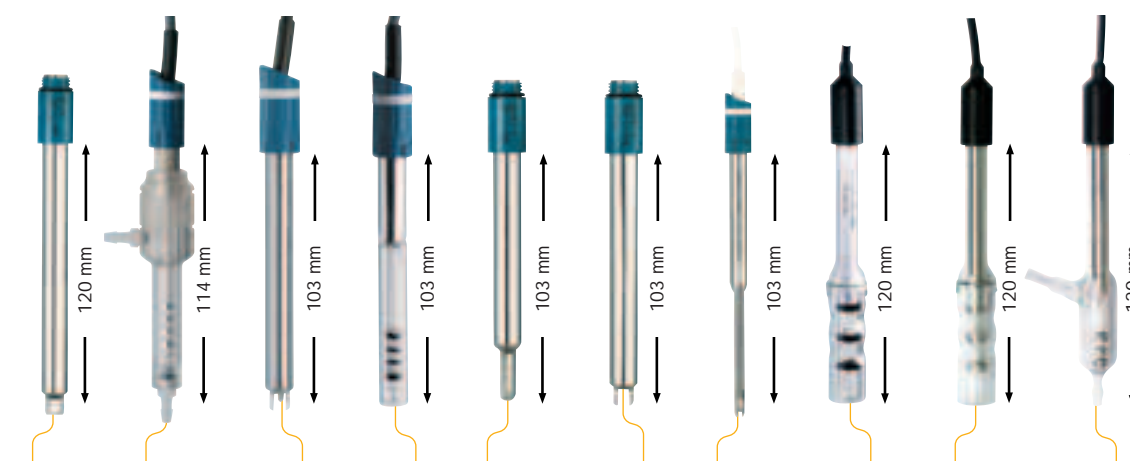
7) Diameter below the head

8) Use adapter part no. A94P001

9) The cell constant is determined experimentally for each cell and the value is given as a guideline only

Recommended conductivity cells by application

Applications/Characteristics	CDC566T	CDC866T	CDC565	CDC641T	CDC745-9	XE-100	CDC511T	CDC741T	CDC861T	CDC267-9	CDC241-9	CDC749	CDC104	CDC304	CDC114
Wide conductivity range (general purpose)	✓	✓	✓					✓							
Various aqueous and non-aqueous media			✓		✓			✓				✓	✓		
Very strong acids and bases								✓							
Use with sample changer							✓								
Built-in temperature sensor	✓	✓	✓			✓	✓	✓							
Continuous measurements			✓		✓					✓					
Microsamples											✓				✓
Flow measurements						✓									✓
Titration										✓					
Salinity (high conductivity)		✓						✓							
Pure water							✓								
Meets requirements of USP 24-NF19			✓			✓									
Use in glass tubes											✓				
Plastic body	✓	✓	✓		✓	✓									
Viscous media										✓					
Highly resistant media									✓						
Field use	✓	✓	✓		✓										



	Pure water	Sample changer	Strong acids, bases	Resistant media	Viscous Titration	Micro-samples	Immersion	Pipette
XE100	CDC511T	CDC741T	CDC861T	CDC267-9	CDC241-9	CDC749	CDC104	CDC304
	E61M009	E61M012	E16M016			E61M014	945-000	945-002
								945-001
B60E100				E61M011	E61M008			
Glass	TPX [®]	Glass	Glass	Glass	Glass	Glass	Glass	Glass
1.0	1.0	1.0	1.0	0.1	1.0	1.7	1.0	1.0
2	4	2	4	2	2	2	3	3
YES	NO	YES	YES	NO	NO	YES	YES	NO
NO	YES	YES	YES	NO	NO	NO	NO	NO
12 mm	12 mm	12 mm	12 mm	12 mm	12 mm	4 mm	10.5 mm ^{?)}	10.5 mm ^{?)}
100°C	80°C	100°C	100°C	100°C	100°C	100°C	100°C	100°C
10 mm	3 ml ^⑥	10 mm	35 mm	26 mm	10 mm	4 mm	55 mm	55 mm
YES ^⑨	YES	YES	YES	YES ^⑨	YES ^⑨	YES	YES ^⑨	YES ^⑨
YES ^⑨	YES	YES	YES	YES ^⑨	YES ^⑨	YES	YES ^⑨	YES ^⑨
NO	NO	NO	NO	NO	YES ^⑨	NO	YES	YES
YES ^⑨	NO	YES ^⑨	NO	YES ^⑨	YES ^⑨	YES ^⑨	YES	YES

Part no.	Accessory
X31M013	Epoxy tube for CDC566T/CDC866T, diameter 12 mm
X51M001	Glass tube for CDC566T/CDC866T, diameter 12 mm
X91M001	Set of accessories for CDC511T (pipe, adapters, syringe, stoppers)
X31M014	Circulation/pipette piece for CDC511T with set of accessories

Certified pH and Conductivity Standards

Radiometer Analytical is accredited for the calibration of both pH and conductivity standards giving you complete confidence in the traceability of your solutions to national standards.

This accreditation by the French national accreditation body, Cofrac⁽¹⁾, is recognised in more than 20 countries worldwide through the EA (European Co-operation for Accreditation).

The IUPAC Series pH standards delivered by Radiometer Analytical are fully traceable to the Standard Hydrogen Electrode through Certified Reference Material produced by the Primary Laboratory of either NIST⁽²⁾ or Radiometer Medical A/S⁽³⁾.

Our conductivity standards are fully traceable to SI units via Certified Reference Materials manufactured by NIST. They are prepared and calibrated according to the internationally recognised demal scale laid down by the Organisation Internationale de Métrologie Légale (OIML).

Standards are delivered in airtight cans to ensure long shelf life.

Guaranteed lifetime

4 years⁽⁴⁾ from the date of issue of the certificate for pH and 2 years for conductivity standards.

A useful reference

a pH or conductivity temperature dependence table is printed on the bottle.

Proper documentation

the date of each use can be recorded directly on the bottle in line with Good Laboratory Practice.

Safe storage
thanks to the airtight tin.

Convenience
the date of opening can be marked directly on the bottle making it easy to follow GLP.

Proven traceability
each standard comes with its own Certificate of Conformity and Traceability (see opposite).



Accurate values

the nominal value of pH standards is given with a resolution of 3 significant decimals. The tolerance is specified taking into account the expanded uncertainty ($k=2$).

Foolproof calibration

each bottle of pH standard is supplied with 25 colour-coded beakers.

International accreditation

a Cofrac Verification Certificate shows the traceability to national standards (see opposite).

Recommended shelf life

the observed typical shelf life after opening is printed on the bottle, ensuring timely use (2-3 months depending on the standards).

(1) Comité Français d'Accréditation.

(2) National Institute of Standards and Technology, Gaithersburg, USA.

(3) The Chemical Reference Laboratory of Radiometer Medical A/S, Copenhagen is accredited for pH measurements by the Danish Accreditation Scheme (DANAK) (no. 119).

(4) 2 years for pH 12.45.



When you purchase a bottle of certified pH or conductivity standard manufactured by Radiometer Analytical you receive proof of the quality.

Delivered with each bottle is a Certificate of Conformity and Traceability drawn up according to ISO Guide 31 which gives full traceability information including the batch number of the NIST or Radiometer Medical A/S Certified Reference Material as well as the composition and preparation of the standard and provides recommendations for storage and use.

Each bottle is also supplied with a Cofrac Verification Certificate, which guarantees traceability to national standards.



IUPAC Series certified pH standards

Type	Value*	Qty	Part No.
pH1.679	pH 1.679 ±0.010 at 25°C	500 ml	S11M001
pH4.005	pH 4.005 ±0.010 at 25°C	500 ml	S11M002
pH6.865	pH 6.865 ±0.010 at 25°C	500 ml	S11M003
pH7.000**	pH 7.000 ±0.010 at 25°C	500 ml	S11M004
pH7.413	pH 7.413 ±0.010 at 25°C	500 ml	S11M005
pH9.180	pH 9.180 ±0.010 at 25°C	500 ml	S11M006
pH10.012	pH 10.012 ±0.010 at 25°C	500 ml	S11M007
pH12.45	pH 12.45 ±0.05 at 25°C	500 ml	S11M008

Certified conductivity standards

Type	Value*	Qty	Part No.
KCl 1D	111.3 mS/cm ±0.5% at 25°C	500 ml	S51M001
KCl 0.1D	12.85 mS/cm ±0.35% at 25°C	500 ml	S51M002
KCl 0.01D	1408 µS/cm ±0.5% at 25°C	500 ml	S51M003
NaCl 0.05%	1015 µS/cm ±0.5% at 25°C	500 ml	S51M004

* Tolerance specified taking into account the expanded uncertainty with k=2.
 ** Radiometer Analytical formulation.

MeterLab Solution Kit

(Part no. S91M002)

To help you obtain accurate calibrations with your Red Rod electrodes: six certified IUPAC pH standards, coloured beakers, beaker dispenser and beaker holder, KCl•L solution and KCl•C crystals.

More Solutions for pH and conductivity

For less demanding environments, we offer cost-effective **4-7-10 Series** buffers manufactured to Radiometer Analytical specifications.

Radiometer Analytical also produces a range of **molar KCl solutions** for calibrating conductivity cells.

4-7-10 Series

Type	Value	Qty	Part No.
pH4.00	pH 4.00 at 25°C	500 ml	S11M012
pH7.00	pH 7.00 at 25°C	500 ml	S11M013
pH10.00	pH 10.00 at 25°C	500 ml	S11M014



Molar KCl solutions

Type	Value	Qty	Part No.
KS910	0.1 M KCl (12.88 mS/cm at 25°C)	500 ml	C20C250
KS920	0.01 M KCl (1.413 mS/cm at 25°C)	500 ml	C20C270
KS930	0.001 M KCl (148 µS/cm at 25°C)	500 ml	C20C280



pH Meter Solution Kit

(Part no. S91M003)

To help you obtain accurate calibrations with your pH C3xxx or REF3xx electrodes: three 4-7-10 Series buffers plus KCl•Ag filling solution.

Electrode Maintenance

Proper maintenance of electrodes means accurate and reproducible pH results and longer lifetime. To ensure you get the best possible performance from your electrode, Radiometer Analytical offers a complete kit plus a selection of maintenance and filling solutions.



GK ANNEX Electrode Maintenance Kit

The GK ANNEX Electrode Maintenance Kit (Part no. S91M001) contains all you need for regular maintenance of combined pH, glass and reference electrodes with saturated potassium chloride salt-bridge:

- ✓ Solutions for normal and intensive cleaning,
- ✓ KCl as saturated solution and crystals for refilling,
- ✓ GLP•Logbook to keep note of calibration and maintenance procedures,
- ✓ Utensils and easy-to-follow instructions.

Maintenance solutions

The maintenance requirements of electrodes vary according to the application. After measurements in aqueous solutions, cleaning with a mild solution such as ○RENOVO•N is sufficient. However, when the solutions contain protein, for example, stronger cleaning agents such as □RENOVO•X or Pepsin in HCl are required. For junctions contaminated with sulphides or AgCl precipitate, Radiometer Analytical's Thiourea Solution is ideal. The operating instructions provide cleaning instructions for each type of electrode.

Type	Description	Part No.
○RENOVO•N	Normal Cleaning Solution, 250 ml	S16M001
□RENOVO•X	Xtra Strong Cleaning Solution, 250 ml	S16M002
KS400	Pepsin in HCl Solution, 250 ml	C20C370
KS410	Thiourea Solution, 250 ml	C20C380

Filling and storage solutions

Electrode operating instructions contain full information about short and long-term storage of electrodes as well as tips on replenishing the salt-bridge where appropriate. Remember to rinse your electrode thoroughly in distilled water and seal the filling hole before putting it away. The instructions tell you whether to store the sensing element dry or in a particular solution. Follow them carefully as the lifetime of your electrode depends on its correct maintenance and storage.

Selecting the right


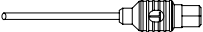


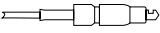



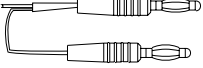


Reference element	Solutions
Red Rod	KCl•L and KCl•C KS100 and KCl•C
Ag/AgCl (pHC3xxx /REF3xx)	KCl•Ag KS120
Ag/AgCl (XCxxx/ XRxxx)	KCl•L and KCl•C KS100 and KCl•C
Calomel	KS160
Hg/Hg ₂ SO ₄	KS160

Filling and storage solutions for combined and reference electrodes

Type	Description	Part No.
KS100	Saturated KCl Solution, 500 ml	C20C300
KCl•L	Saturated Solution of KCl, 100 ml	S21M002
KCl•L-30	Saturated Solution of KCl, 30 ml	S21M010
KCl•C	KCl Crystals, 15 g	S21M001
KCl•Ag	3M KCl Solution Saturated with AgCl, 100 ml	S21M004
KCl•Ag-30	3M KCl Solution Saturated with AgCl, 30 ml	S21M011
KS110	KCl Solution 3M, 500 ml	C20C320
KS120	Saturated KCl + AgCl Solution, 500 ml	C20C310
KS120-30	Saturated KCl + AgCl Solution, 30 ml	S21M009
KS160	Saturated K ₂ SO ₄ Solution, 500 ml	C20C500
KS160-30	Saturated K ₂ SO ₄ Solution, 30 ml	S21M007
LiCl-30	1M LiCl Solution, 30 ml	S21M008

Accessories

Connection cables for screw cap electrodes




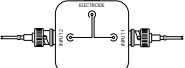

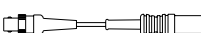
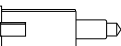

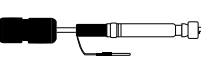
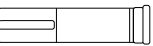




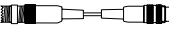

Instrument socket	Type	Part no.
banana		CL111 A94L111
P2		CL112 A94L112
DIN		CL113 A94L113
BNC		CL114 A94L114
Type 7		CL116 A94L116
P2 + banana		CL117 A94L117
US + banana Ø 2 mm		CL118 A94L118
UHF (PL259)		CL119 A94L119
2 x banana		CL120 A94L120
LEMO Ø 2 mm		CL129 A94L129
MAB6		CL136 A94L136

Note: Standard cable length is 1 m.
* 617-521: 2 m,
617-522: 5 m,
617-523: 10 m.

Other accessories

Part no.	Description
X31M012	Conical joints for 12 mm diameter electrodes, polyethylene, set of 4 pcs.

Plug adapters

Electrode plug	Instrument socket	Part no.
BNC		Type 7 A94P800
Type 7		BNC A94P802
2 x banana		BNC A94P801
BNC (pH Electrode)		2 x BNC A94P803
2 x BNC		BNC A94P804
BNC		DIN A94P806
Type 7		Type 4 809-144
Type 7		DIN 617-527
Type 7		US sep. terminals 617-526
Type 7		US 809-190
banana		US 803-109
banana		Type 7 809-147
US		Type 7 617-524
Extension cable (Type 7)		Type 7 617-520*
UHF		MAB6 A94P001
MAB6		UHF+PYE A94P002



Leading the field in electrochemistry

Radiometer Analytical SAS develops, manufactures and distributes an extensive range of electrochemical systems dedicated for routine testing, research and teaching in the laboratory and on the plant.

By supplying instruments, software, sensors and calibration standards, Radiometer Analytical SAS masters the complete measuring chain. Our customers obtain a reliable result at reasonable cost thanks to all-in systems that are easy to use and maintain.

The company enjoys a reputation for excellence in the following fields:

pH, ion and conductivity measurements: complete systems for reliable measurements in the field and in the lab including a wide choice of instruments, sensors and standards.

Titration: workstations customised to individual applications including titrators, sample changers and dedicated software.

Voltammetry: all-in systems for electrochemical measurements including potentiostats, impedance meters and powerful software

making use of techniques such as voltammetry, amperometry, coulometry, polarography and EIS.

Radiometer Analytical SAS has been building its expertise for more than sixty years since the company pioneered its very first pH meter in Copenhagen, Denmark. It was strengthened by the acquisition of Tacussel, another leading name in electrochemical instrumentation. More recently Radiometer Analytical SAS joined the Danaher Corporation.

Based in Lyon, France, Radiometer Analytical SAS is represented throughout the world by a network of experienced, factory-trained distributors, who can offer comprehensive applications and after-sales service.

Radiometer Analytical SAS is ISO 9001 certified. In addition, our Reference Materials Laboratory is accredited by COFRAC (Comité Français d'Accréditation) for the calibration of reference materials in pH and conductivity (Accreditation No. 2.1418).

Un grand savoir-faire en électrochimie

Radiometer Analytical SAS conçoit, fabrique et distribue une gamme complète d'ensembles électrochimiques de laboratoire et de terrain dédiés à l'analyse de routine, la recherche et l'enseignement.

En fournissant à ses utilisateurs des instruments de mesure, logiciels, capteurs et solutions d'étalonnage, Radiometer Analytical SAS maîtrise l'ensemble de la chaîne de mesure. Cela garantit des résultats fiables avec des ensembles complets et faciles à utiliser et entretenir, à un coût raisonnable.

Notre société a acquis une solide réputation grâce à son savoir-faire dans les domaines suivants :

pH-métrie, ionométrie et conductimétrie : des ensembles complets pour des mesures fiables en laboratoire ou sur le terrain comprenant un large choix d'instruments, de capteurs et de solutions étalons.

Titration : des stations de travail adaptées en fonction de chaque type d'application incluant des titrateurs, des passeurs d'échantillons et un logiciel spécifique.

Voltamétrie : des systèmes "tout-en-un" pour effectuer des mesures électrochimiques, comprenant des potentiostats, des impédance-

mètres et un logiciel puissant, et permettant l'utilisation de techniques telles que la voltamétrie, l'ampérométrie, la coulométrie, la polarographie et l'EIS.

Depuis la fabrication de son premier pH-mètre à Copenhague il y a plus de soixante ans, Radiometer Analytical SAS a constamment développé sa maîtrise et son expertise dans le domaine de l'électrochimie et a renforcé sa réputation par l'acquisition de Tacussel, une autre marque leader dans l'instrumentation électrochimique. Plus récemment, Radiometer Analytical SAS a rejoint le groupe Danaher Corporation.

Basée à Villeurbanne (Rhône), Radiometer Analytical SAS est représentée par un vaste réseau de distributeurs en France et dans le monde, qui peuvent répondre rapidement à toutes les demandes commerciales, techniques, applicatives et de service après-vente.

Radiometer Analytical SAS est certifiée ISO 9001. De plus, notre Laboratoire Matériaux de Référence est accrédité par le COFRAC (Comité Français d'Accréditation) pour l'étalonnage de matériaux de référence pour les mesures de pH et de conductivité (Accréditation N° 2.1418).

Führend auf dem Gebiet der Elektrochemie

Radiometer Analytical SAS entwickelt, fertigt und vertreibt ein umfangreiches Programm elektrochemischer Laboranalytensysteme, die für Routineprozesse genauso geeignet sind, wie für Ausbildung und Forschung.

Radiometer Analytical SAS bietet komplette Lösungen. Diese sind speziell den Kundenanforderungen angepasst und gewährleisten in der täglichen Routine einfache Handhabung, hohe Sicherheit und zuverlässige Analysenergebnisse.

Die Firma verfügt insbesondere auf folgenden Gebieten über einen hervorragenden Ruf:

pH-, Ionen- und Leitfähigkeitsmessungen: MeterLab sind komplette Messplätze für zuverlässige Analysen im Feld und im Labor, mit einem breiten Angebot von Instrumenten, Sensoren und Standards.

Titration: TitraLab sind leistungsfähige Titrationsautomaten, die den individuellen Anforderungen angepasst werden können. Endpunkt-, Wendepunkt-, pH-stat- oder Karl Fischer- Titratoren, ausgestattet mit modernster Technik, stehen zur Verfügung. Soft-

waregesteuert lassen sich diese Titratoren kombinieren oder durch Zusatzbüretten und einem Probenwechsler weiter ausbauen.

Elektrochemische Messsysteme: VoltaLab sind Komplettsysteme, die allen Anforderungen gerecht werden. Alle Potentiostate der VoltaLab- Serie werden über die gleiche Software gesteuert. Elektrochemischen Methoden wie Voltammetrie, Amperometrie, Coulometrie oder EIS- Impedanzmessungen können auf diese Weise sinnvoll verknüpft werden.

Radiometer Analytical SAS profitiert von seinen im Verlauf von über 60 Jahren erworbenen Erfahrungen. Am Anfang stand der Bau eines bahnbrechenden pH-Meters in Kopenhagen. Die Position der Firma wurde durch den Erwerb von Tacussel, einer bekannten Firma auf dem Gebiet der Elektrochemie, weiter gestärkt. In jüngster Zeit schloss sich Radiometer Analytical SAS der Danaher Corporation an.

Die von Lyon aus operierende Firma Radiometer Analytical SAS wird weltweit durch ein Netz erfahrener, im Werk ausgebildeter Fachkräfte vertreten, die vor Ort bei Anwendungen und Kundendienst umfangreiche Unterstützung gewähren können.



RADIOMETER ANALYTICAL SAS
72 rue d'Alsace, 69627 Villeurbanne Cedex, France
E-mail: radiometer@analytical.com Web: www.radiometer-analytical.com
Tel.: +33 (0)4 78 03 38 38 - Fax: +33 (0)4 78 68 88 12