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## Background

Electrical conductivity is an inherent property of most materials, and ranges from extremely conductive materials like metals to highly resistive materials such as polymers or glass. Aqueous solutions, such as sea water and plating baths exhibit conductivity between these two extremes. In aqueous solutions, the electrical current is carried by charged ions. The conductivity is determined by the number of charge carriers, how fast they move, and how much charge each one carries. Hence, for most aqueous solutions, the higher the concentration of dissolved salts, which will lead to more ions, the higher the conductivity. This effect continues until the solution gets to a maximum value, after which, the conductivity may actually decrease with increasing concentration. This can result in two different concentrations of a salt having the same conductivity. This needs to be considered when using conductivity to determine concentrations of solutions. Some species ionize more completely in water (strong electrolytes such as NaCl & HCl) than others do, and their solutions are more conductive as a result. Each acid, base, or salt has its own characteristic curve for concentration vs. conductivity. Raising the temperature gives more energy to the ions making them move faster, and hence increasing the conductivity.. Since ions are of different sizes, and carry different amounts of water with them as they move, the temperature effect is different for each ion. Typically, the conductivity varies about 1–3% per degree C, and this temperature coefficient may itself vary with concentration and temperature.

## Definitions

The conductivity of a material is an inherent property. Pure water at a particular temperature will always have the same conductivity. The conductance of a sample of pure water depends on how the measurement is made—how big a sample, how far apart the measuring electrodes are, etc. It is defined as the reciprocal of the resistance in ohms, measured between the opposing faces of a 1 cm cube of liquid at a specific temperature. See Conductivity Cell Figure. The basic unit of conductance is

the Siemens (S). Because a measurement gives the conductance, techniques have been worked out to convert the measured value to the conductivity, so that results can be compared from different experiments. This is done by measuring a cell constant (K) for each setup, using a solution of known conductivity.

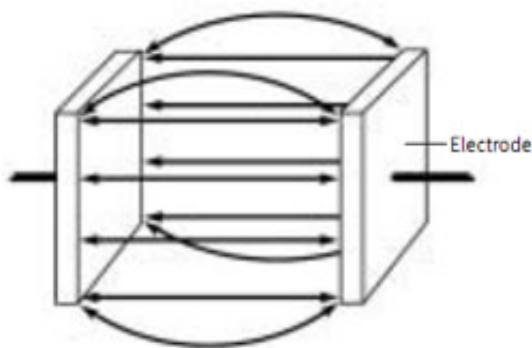
**Cell Conductance x Cell Constant (K) = Conductivity**

(Equation 1)

The cell constant is related to the physical characteristics of the measuring cell. K is defined for two flat, parallel measuring electrodes as the electrode separation distance (d) divided by the electrode area (A). Thus, for a 1 cm cube of liquid:-

**$K = d/A = 1 \text{ cm}^{-1}$**

(Equation 2)



In practice, the measured cell value is entered into the meter, and the conversion from conductance to conductivity is done automatically. The K value used varies with the linear measuring range of the cell selected. Typically, a cell with  $K = 0.1 \text{ cm}^{-1}$  is chosen for pure water measurements, while for environmental water and industrial solutions a cell with K of 0.4 to  $1 \text{ cm}^{-1}$  is used. Cells with up to  $K = 10 \text{ cm}^{-1}$  are best for very high conductivity samples. For some solutions, such as pure water, the conductivity numbers are so low that some users prefer to use resistivity and resistance instead. The resistivity is the reciprocal of the conductivity ( $R = 1/C$ ), and the resistance is the reciprocal of the conductance. Resistance units are in ohms, and  $1 \text{ ohm} = 1/\text{Siemens}$ . From Eq. 1 and 2, it can be seen that conductivity units are in Siemens/cm, and therefore resistivity units are in  $\text{ohm-cm}$ .

The resistivity of ultrapure water is 18 megaohm-cm.

## How is conductivity measured?

In the simplest arrangement (a 2-electrode cell), a voltage is applied to two flat plates immersed in the solution, and the resulting current is measured. From Ohm's Law, the conductance = current/voltage. Actually there are many practical difficulties. Solution conductivity is due to ion mobility. Using DC voltage would soon deplete the ions near the plates, causing polarization, and a higher than actual resistance. This can be mostly overcome by using AC voltage, but then the instrument designer

must correct for various capacitance and other effects. Modern sophisticated 2-electrode conductivity instruments use complex AC waveforms to minimize these effects, and by using the cell constant, measured temperature, temperature coefficient and reference temperature, will report sample conductivity.

## Durability

Cell materials should be chosen to fit the needs of the application. For field and demanding laboratory applications, many users choose a cell constructed with an epoxy body and carbon measuring electrodes, as this has been shown to be extremely durable and chemically resistant. For especially demanding applications, some manufacturers supply probe guards, which can be attached to the probe for additional protection. For pure water applications such as USP injectable water testing, stainless steel is the material of choice. It is very durable, can be manufactured to precise tolerances, and for low conductivity, low contact resistances are not required. For chemically reactive samples, glass and platinum are frequently the optimum choice, as they have the best overall chemical resistance of all commonly used cell materials

**Table 1 Typical Conductivities of Common Solutions**

Sample at 25 °C	Conductivity, $\mu\text{S}/\text{cm}$
Ultrapure Water	0.055
Distilled Water	1.0
Rain Water	50
Drinking Water	500
Industrial Wastewater	5,000
Seawater	50,000
1M NaCl	85,000
1M HCl	332,000

**Table 2 - TC (Temperature Coefficient Values)**

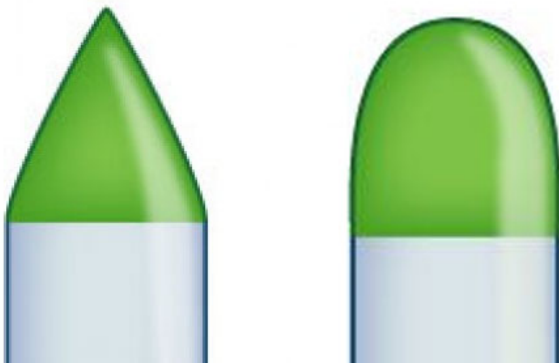
Sample	Percent/ $^{\circ}\text{C}$ (at 25 $^{\circ}\text{C}$ )
Ultrapure Water	4.55
Salt solution (NaCl)	2.12
5% NaOH	1.72
Dilute Ammonia Solution	1.88
10% HCl	1.32
5% Sulfuric Acid	0.96
98% Sulfuric Acid	2.84
Sugar Syrup	5.64



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## IJ Series

Intermediate Junction Electrodes

Setting the benchmark in super-long life, versatility and value for money since 1972, the flagship of the Ionode Lab sensor range is the renowned IJ Series.

Built to exacting standards and available in pH, ISE, ORP and Reference, the IJ Series benefits are many ... A removable sleeve and renewable junction for longer life and easy cleaning, an isolated secondary reference to effectively defeat contamination, an annular ground-glass junction to provide

fast response times and resistance to clogging, selectable electrolyte and an optional toughened glass spear membrane for direct penetration. An exceptional choice in virtually any sample, the IJ Series is unequalled in food, wine, dairy, contaminated waste samples, industrial, mining, petro-chemical, electro plating and countless more. The IJ Series also features models with solvent resistant bodies and high temperature housings for the most demanding of environments.

- ✔ Replaceable electrolyte
- ✔ Removeable sleeve
- ✔ Available for pH, ISE & ORP
- ✔ Polypropylene body

## Way back In 1972,

History of the Intermediate Junction

Back in 1972, Ionode's R&D Chemists and Engineers set out to develop a sensor that would solve the the common problems of contamination and clogging etc. but still be tough, fast and super reliable. Working together, they decided it was possible and they set to work on what would become the IJ Series ... a sensor that would defeat contamination, work in any sample and have a lifetime far in excess of other single or double junction sensors. The benchmark in sensor versatility, reliability and performance was then born in the IJ Series. Featuring an renewable intermediate junction for easy cleaning, Ionode's proprietary glass formulae and a tough yet flexible body, the IJ Series quickly earned it's reputation for having the longest life in the industry and being the best value sensor available.

### More Junctions, Less Contamination

IJ have unique junction mechanics which protect the primary reference from the contamination associated with traditional gel electrodes whilst providing the low maintenance and long life of a refillable sensor.

### Removeable Sleeve

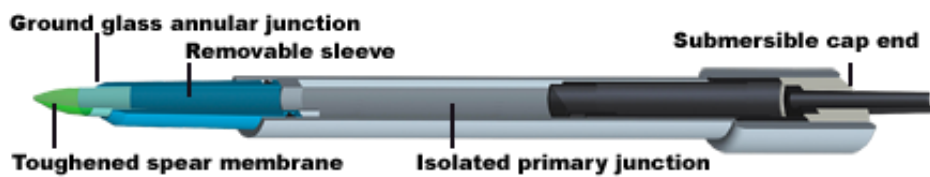
IJ electrodes have a removeable sleeve to make cleaning quick and easy.

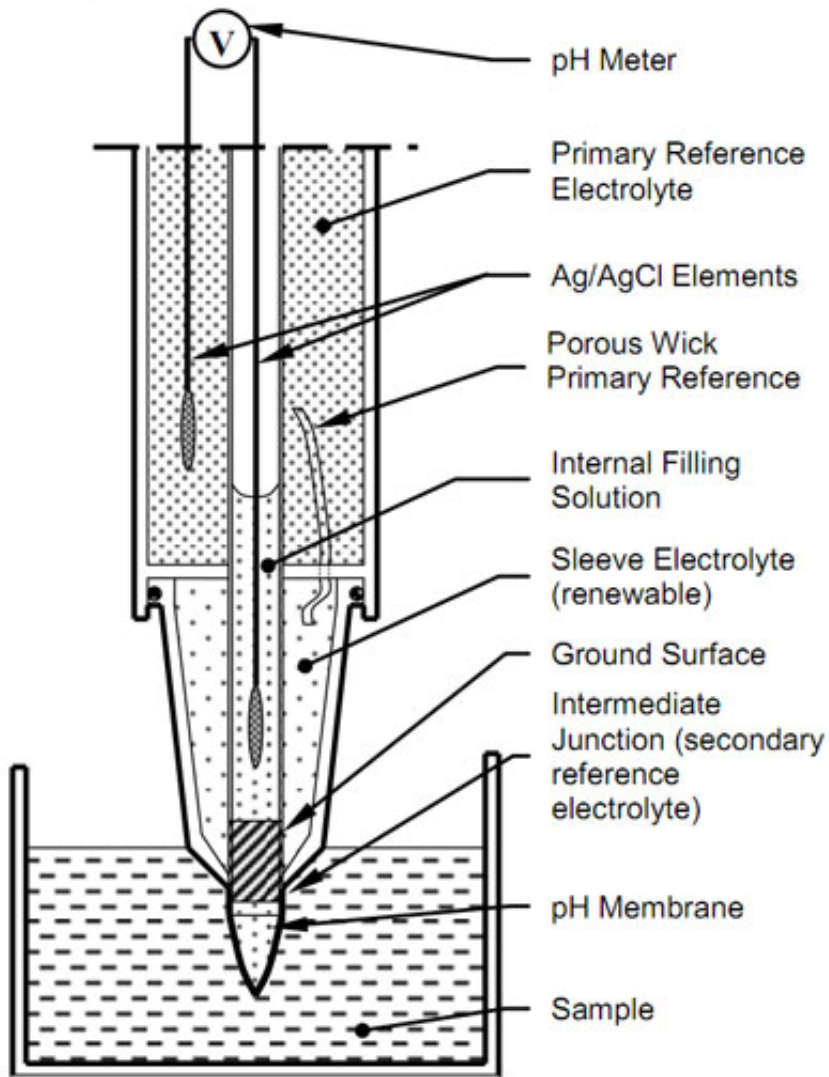


## IJ's Explained

Why you need an intermediate junction probe

IJ's have unique junction mechanics which protect the primary reference from the contamination associated with traditional gel electrodes whilst providing the low maintenance and long life of a refillable sensor.





# The IJ Range

The full range of IJ electrodes

Model	Parameter	Measuring Range	Temp. Range	Sensor Type	Temperature Compensation
IJ14	Ref		0 - 60	Reference	n/a
IJ44-Spear	pH	pH 0 - 14	0 - 60	A glass spear	Optional
IJ44-HT-Spear	pH	pH 0 - 14	0 - 100	A glass spear	Optional
IJ40	pH	pH 0 - 14	0 - 60	A glass bullet	Optional

← Swipe to see more information

<b>IJ40-ALK</b>	pH	pH 0 - 14	0 - 60	C Glass bullet	Optional
<b>IJ40-HT-ALK</b>	pH	pH 0 - 14	0 - 100	C Glass bullet	Optional
<b>IJ64</b>	ORP	±2000mV	0 - 60	Platinum Wire	n/a
<b>IJ64D</b>	ORP	±2000mV	0 - 60	Platinum Disc	n/a
<b>IJ64-HT</b>	ORP	±2000mV	0 - 100	Platinum Wire	n/a
<b>IJAg</b>	Ag <sup>+</sup> , Cl <sup>-</sup>	±2000mV	0 - 60	Silver Billet	n/a
<b>IJAu</b>	ORP	±2000mV	0 - 60	Gold Wire	n/a



<b>Model</b>	<b>Parameter</b>	<b>Measuring Range</b>	<b>Temp. Range</b>	<b>Main Interferences</b>	<b>Slope</b>
<b>IJ-F</b>	F <sup>-</sup>	0.2 - 19,000 ppm	0 - 60	OH <sup>-</sup>	57mV/decade ± 5mV
<b>IJ-Ag2S</b>	S <sup>2-</sup>	0.003 - 32,000 ppm	0 - 60	Hg <sup>+2+</sup>	27mV/decade ± 3mV
	Ag <sup>+</sup>	0.01 - 108,000 ppm			57mV/decade ± 5mV
<b>IJ-Cl</b>	Cl <sup>-</sup>	1.8 - 35,500 ppm	0 - 60	Br <sup>-</sup> , I <sup>-</sup> , S <sup>2-</sup> , CN <sup>-</sup> , S <sub>2</sub> O <sub>3</sub> <sup>2-</sup>	57mV/decade ± 5mV
<b>IJ-Br</b>	Br <sup>-</sup>	0.2 - 79,900 ppm	0 - 60	I <sup>-</sup> , S <sup>2-</sup> , CN <sup>-</sup>	57mV/decade ± 5mV
<b>IJ-I</b>	I <sup>-</sup>	0.005 - 127,000 ppm	0 - 60	S <sup>2-</sup> , CN <sup>-</sup>	57mV/decade ± 5mV
<b>IJ-CN</b>	CN	0.2 - 260,000 ppm	0 - 60	S <sup>2-</sup> , I <sup>-</sup>	57mV/decade ± 5mV



