WATERPROOF

pH / CONDUCTIVITY METER

CPC- 411

USER'S MANUAL

ELMETRON

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pH / CONDUCTIVITY METER
CPC-411

Before use please read the instruction carefully.

CONTENTS

I. INTRODUCTION

1. EXPLOITATION NOTICES

Dear User!

We present you a device distinguished by accuracy according to the technical data and by a high stability of the displayed results. We believe that the measurements would not cause you any trouble and that the meter would operate without any inconvenience. **Wide range of additional functions requires careful reading of the manual, in other case some of the features may stay unused or using the meter may be troublesome.**
Using good-quality electrodes, cells and probes and replacing them after a suitable time ensures obtaining of high measuring parameters. It is worth remembering that this equipment has a much shorter working life than the meter. Deterioration of the result stability and increase of the measuring error are typical symptoms of an improper work of the electrode. **Some problems users have may arise from using pH electrodes not being conditioned before the measurement, making measurements not having removed the shielding ring from the liquid junction, with contaminated membrane or plugged junction.** To avoid such situations it is necessary to choose a proper kind of electrode for solutions which are going to be measured, e.g., sewage, liquids with deposits, meat, cheese etc. Therefore, if you observe improper operation of the device, please take control measurements with another electrode. **In most cases deterioration of the meter's work is caused by the electrode and not by the meter itself.**
In case of conductivity measurements it is important to choose the cell with the K constant value suitable for the measuring range. Improper selection may cause increase of the readout error.

The essential feature of our products is their low failure frequency. However, in case of the meter's failure, our firm provides its immediate repair under the warranty conditions.
We wish you pleasant and trouble-free work with our meter.

2. CHARACTERISTICS OF THE METER

The **CPC-411** pH/conductivity meter belongs to the newest generation of measuring devices which offer wide range of additional functions. The meter ensures high accuracy and repeatability of readings and is easy-in-use. Two kinds of power source: battery and power adapter enable work in field and long-lasting measurements in the laboratory. Electronic elements of the newest generation used in the meter have made its memory independent from power supply and have ensured very low power consumption what greatly prolongs the operation time on 1 battery.
The meter is equipped with large custom LCD display, on which pH, redox potential (mV), conductivity or temperature readout is displayed. Waterproof housing makes working in difficult conditions possible. Minimised size and weight make the meter very handy especially during field work.

Main features of **CPC-411** are:
- high accuracy and stability of readings;
- automatic temperature compensation;
- pH electrode calibration in 1 to 3 points;
- automatic recognition of pH buffers and standards;
- calibration of the conductivity cell by introducing the K constant or on standard solutions;
- possibility of determining K constant of the cell;
- storing the parameters in non-volatile memory;
- co-operation with Pt-1000 temperature sensor;
- system protecting the meter against damages caused by connecting the battery inversely and information about the battery condition ();
- automatic switch off function.

3. WHAT IS THE METER DESIGNED FOR

Waterproof pH/conductivity meter **CPC-411** is precise and easy-to-use meter designed for hydrogen ion concentration measurements in pH units, redox potential measurements in mV units, conductivity measurements in µS/cm or mS/cm and for accurate temperature measurement of solutions and air in °C. The conductivity result may be calculated for 25^0C or 20^0 (for measurements in honey) or for NaCl or TDS content in g/l. The meter is useful both for work in the field and measurements in the laboratory. Waterproof housing enables work in difficult weather conditions or in humid environment.
The **CPC-411** pH/conductivity meter is used in food, chemical, pharmaceutical and power industries, in water treatment stations, laboratories, agriculture, universities, scientific laboratories etc.

The meter is prepared to work with all types of combination pH electrodes and conductivity sensors equipped with BNC-50 connector. It is possible to connect the meter with two electrodes (pH measuring and reference) by special adapter offered as additional equipment. **CPC-411** co-operates with Pt-1000 temperature probe with Chinch connector.

4. THE OUTSIDE VIEW

On the front wall of the meter there is an LCD display (Pic. 1) which shows, depending on the chosen function:
- result of the pH measurement in pH units;
- result of the redox potential measurement in mV;
- result of the conductivity measurement calculated for 25^{0}C;
- result of the salinity measurement in g/l calculated to NaCl;
- result of the salinity measurement in g/l calculated to TDS;
- result of the honey conductivity measurement calculated for 20^{0}C.

The way of choosing functions is described in the chapter 6.1.

Simultaneously, below the readout, the temperature value in ^{0}C is displayed. Symbols of units are displayed next to the readout.
In case of disconnecting the temperature probe the meter switches to manual temperature compensation mode (the symbol disappears). The battery condition is signalised by the symbol. The keyboard placed below the display is used for switching the meter on and off, choosing the measuring function, calibration and entering the parameters.

The keyboard has the following keys:

- switching the meter on and off;

- pressing shortly enters the mode of choosing the measurement function; holding returns the meter to the measurement mode;
- holding enters the mode of switching between the main measuring functions: pH, mV and conductivity with the  button.

- holding this button enters the calibration mode (**CAL** symbol displayed). Pressing shortly in this mode confirms the calibration result in the calibration point;

 , 

- buttons used for entering parameters.

In the upper wall of the meter there are inputs placed with the symbols given below:

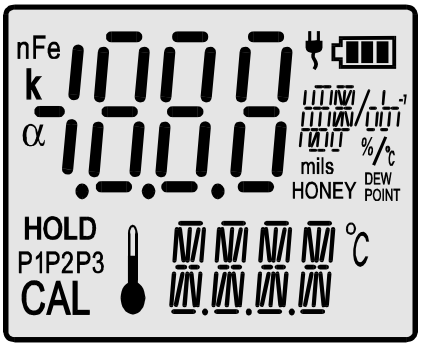
F - the **BNC-50** input for connecting the pH electrode**,** the measuring electrode or the redox electrode;
F1 - the **BNC-50** input for connecting the conductivity cell;
t - the **Chinch** input for connecting the temperature probe;
P - the power adapter input.


F
t
F1
P
ELMETRON
12.68
mS/cm
CAL
22.4 °C
FUNCTION
CAL
ON
OFF
pH/conductivity meter CPC-411
waterproof

Pic. 1

5. SWITCHING THE METER ON AND OFF

After switching it on with the  button, the meter tests the memory and the display on which all symbols are being displayed.



Pic. 2

If the test ends successfully, after about 1.5 s the meter switches automatically to the measuring mode, in which it was switched off. If a HLP sign is displayed, it means that the meter has lost the factory settings and requires service repair. If after the 1,5 s all symbols are continuously displayed, it informs that the calibration parameters of electrodes or cells have been lost.

After pressing the  button the meter adopts standard characteristics:

- drift 0 pH, slope 100% for the pH electrode
- K constant of the conductivity cell K=1.000 cm^{-1}

and enters to the measuring mode. It will be necessary to calibrate the pH electrode and the conductivity cell.
If the situation repeats each time the meter is being switched on, it informs that the manufacturer’s calibration has been lost and the meter should be sent for servicing.

The meter is switched off by pressing the  button. In case of working on batteries, in order to save them, the meter switches automatically off after 10 minutes of non-use. This function is automatically deactivated when working with power adapter.

6. PREPARATION TO WORK

Before starting work:

- connect the power adapter plug to the **P** input, if work with the power adapter is planned;
- in case of pH measurements join the combination pH electrode to the BNC-50 input (**F**);
- in case of using measuring and reference electrode, connect them by the adapter available as an option;
- in case of conductivity measurements, join suitable conductivity cell to the BNC-50 input (**F1**);
- in case of using the temperature probe it should be connected to the Chinch temperature input **t**;
- switch the meter on by pressing the  button.

<u>When measuring pH, the conductivity cell must be disconnected from the meter or taken out of the solution in which the pH electrode is placed!</u>

6.1. Choosing the measuring function

The CPC-411 meter enables pH, redox potential or conductivity measurement.
In order to switch the measuring function:

- press and hold the  until the lower row of the display shows the UNIT symbol and the upper row – currently active measurement function;
- by pressing the  button choose the measuring function:
  - Ph - pH measurement
  - U - redox potential measurement
  - Cnd - conductivity measurement
- by pressing the  return to the measuring mode;

6.2. Choosing the unit

In the conductivity measurement mode the readout may be displayed as:

- conductivity at µS/cm or mS/cm converted to 25°C;
- salinity at g/l converted to NaCl (accordinfg to actual slope);
- salinity in g/l converted to TDS (with use of the W_{TDS} coefficient);
- conductivity of honey at µS/cm or mS/cm converted to 20°C;

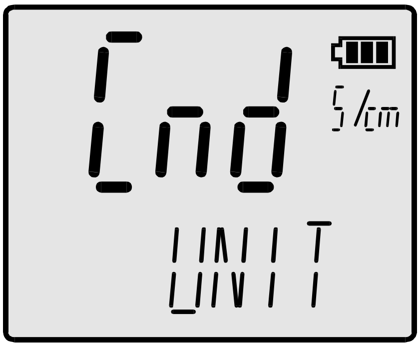
The unit is chosen in the measuring mode by pressing and holding the FUNCTION button, in the buttom row displays the UNIT symbol and in the upper row - the Cnd (conductivity) symbol and the unit (Pic.3). Next, by pressing the button, choose next to the Cnd symbol:

mS/cm - measurement in µS/cm lub mS/cm converted to 25°C;;

g/l - measurement in g/l converted to NaCl;

tdS - salinity in g/l converted to TDS

- mS/cm HONEY - measurement in honey in µS/cm or mS/cm converted to 20°C.

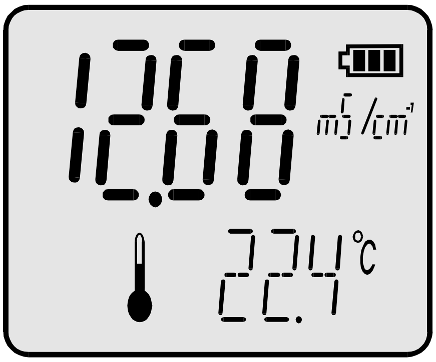


Pic. 3

Return to the measuring mode by pressing the FUNCTION button.

6.3. Choosing the kind of temperature compensation

The meter switches to the automatic temperature compensation mode automatically after connecting the temperature probe. Next to the temperature reading the symbol appears. The measurement will be compensated to the value of temperature measured by the probe
Disconnecting the temperature probe switches the meter to the manual temperature compensation mode (the symbol disappears) and the value of the temperature entered by the user will be adopted for compensation.



Pic. 4

6.3.1. Entering the temperature value for manual temperature compensation

To enter the temperature value for manual temperature compensation:

- disconnect the temperature probe (the symbol disappears);
- with the , buttons enter the requested temperature value

II. pH MEASUREMENT

7. PREPARATION OF THE pH ELECTRODE

The electrode should be prepared to work according to the manufacturer's instructions. If the instructions weren't given please follow the steps:

- new electrode should be put into saturated KCl solution for about 5 hours:
- before starting measurements, protecting rings (if used in this kind of electrode) should be removed. The ring placed on the junction – the lower part of the electrode - should be removed upwards along the electrode's body and the upper, which protects the KCl refilling hole, downwards along the body. **Removing the lower ring is essential, in other case the electrode won't measure.** The upper ring should be removed during measurements of high-temperature solutions or to protect the junction during measurements in solutions with deposits or oils. Sometimes instead of ring a cork is used;
- during measurements in laboratory it is advisable to use an electrode holder;
- after every measurement the electrode should be washed in distilled water;
- excess of liquid on the electrode should be removed by gentle touching the glass with a tissue paper;
- after work the electrode should be stored in the KCl solution. Protecting rings should be put on the junction and the upper hole;
- in case of long breaks between measurements the electrode should be stored, after drying, in the packaging;
- after taking the electrode out of the package the deposit, which is likely to appear, should be removed with use of water;
- before use, the electrode should be placed in saturated KCl solution for about 1 hour;
- if the construction of the electrode enables refilling the electrolyte, it should be controlled and refilled periodically by the upper hole in the electrode's body (usually as the electrolyte a KCl solution is used).
- If the electrode is equipped with a small container (bottle) put on its end, the bottle should be taken off before measurements by unscrewing the nut gently and taking the bottle down the electrode's body. After the measurements the bottle should be put on again. Such electrodes are not equipped with the protective ring on the junction and do not require activating the membrane.

NOTE: storing the electrode in distilled water shortens its lifetime and may enlarge the measurement error.

8. CALIBRATION

Before starting measurement with new electrode, after long-lasting use or before making measurements which require high accuracy, the electrode connected with the meter should be calibrated. Results of measurements made without calibration will be burdened with a significant error. Calibration is made in buffer solutions. It consists in comparing pH value of buffer solutions with the value displayed by the meter and next in automatic introduction of correction which is taken into consideration during next measurements. Calibration should be periodically repeated because the parameters of the electrode are changing while working, what influences accuracy. The frequency of this procedure depends on the demanded accuracy, number of the measurements carried out, conditions in which the electrode is used, temperature and value of the measured solutions. When the highest accuracy is required, it is recommended to use fresh buffer solutions with certificates.

CPC-411 enables calibration in **buffer solutions with values determined by the manufacturer,** which are: 4.00; 7.00 and 10.00 pH, and are automatically detected.

There is a possibility of calibration minimum in 1 point and maximum in 3 points. The more calibration points are used, the higher accuracy in the whole range is ensured.

Calibration in 1 point doesn't guarantee high accuracy. If the accuracy requirements are not very high and the measurement is made in the whole measuring range, one-point calibration should be made with use of 7.00 pH buffer solution. Thanks to this the error connected with so called "zero offset" of the electrode will be eliminated. In the rest of the points a standard slope of the electrode characteristic from the meter's memory will be adopted. This slope corresponds to the theoretical efficiency of pH electrode. In case of accurate measurements in the whole range we recommend three-point calibration. In case of measurements in acids calibration in 2 buffer solutions: 4.00 and 7.00 pH is recommended, in case of alkali measurements calibration in 7.00 and 10.00 pH buffers is advisable.

In **CPC-411** characteristic of the electrode is approximated segmentally between the calibration points.

Starting calibration irreversibly erases the characteristic of calibration stored in the memory.

The buffer solutions may be used in a freely chosen order.

8.1. Calibration with automatic temperature compensation

After preparing the meter to calibration it is necessary in pH function to:

a. press and hold the 

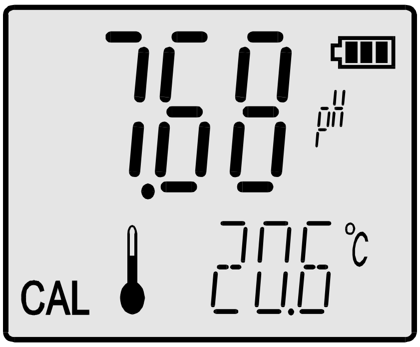
button till the moment of appearance of the *CAL* symbol on the display (Pic. 5), **the previous parameters of calibration are now deleted;**

b. put the electrode and the temperature probe to the standard solution, the meter will recognise the pH value of the standard and the **P1** (calibration point) symbol will appear. The reading may be different than the actual pH value of the standard. After stabilisation of the reading press the 

Blinking of the reading informs about recording the calibration value. At the same time the measured value will be adjusted to the value of the applied buffer solution.
If the value of the applied solution (buffer) is different then the recorded one and cannot be recognised by the meter or the electrode connected to the meter is broken, the Err symbol will appear.

c. the calibration may be finished at this moment by pressing the 

button or continued in other buffer solutions accordingly to the point b. The electrode and the temperature probe should be washed before each immersion in the buffer.

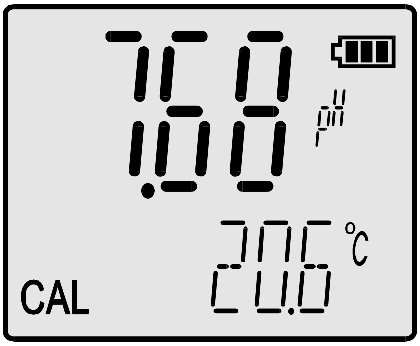


Pic. 5

In case of entering the calibration mode and escaping it not having made calibration at least in one point, previously stored characteristic will be deleted and standard characteristic will be adopted.

8.2. Calibration with manual temperature compensation

Disconnecting the temperature probe switches the meter to manual compensation (the symbol next to the temperature reading disappears). The value of the temperature introduced by the user will be adopted for compensation.
Next, connect the pH electrode to the meter, introduce the actual temperature of the applied buffer solutions according to the point 6.3.1 and act accordingly to the points a ÷ c of the previous chapter.

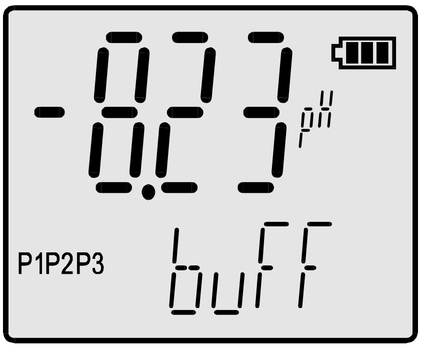


Pic. 6

9. THE ELECTRODE PARAMETERS READOUT

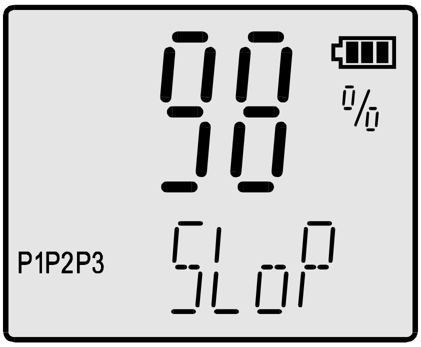
After the pH electrode has been calibrated, it is possible to check its condition: zero offset and slope.
To check, in the pH measurement mode:

- press the button two times, in the lower display row the buFF symbol willl apear, the upper row will show the electrode's zero offset (Pic. 7);



Pic. 7

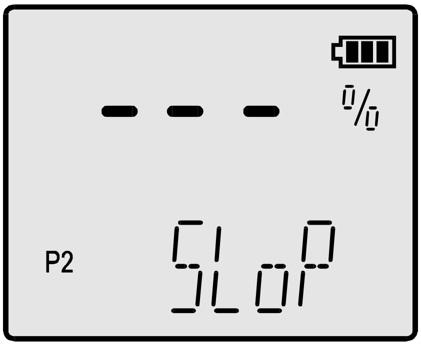
- press the FUNCTION button once again, in the lower row the SLoP symbol will be displayed and the percentage value of the electrode condition - in the upper row. (Pic. 8);



Pic. 8

In the lower left corner of the display the points of the electrode calibration are shown.

After deleting the electrode characteristics (entering the calibration mode and escaping it without calibrating at any point) the meter adopts the ideal electrode characteristics for its calculations and the actual electrode's parameters are unknown. In this case, after entering in the electrode parameters readout mode, in the place of the digital values, lines are displayed.
One-point calibration enables to indicate only the zero offset of the electrode. Instead of the slope value lines are displayed (Pic. 9).



Pic. 9

Escape the electrode parameters readout by pressing and holding the FUNCTION button until the meter returns to the measurement mode.

10. pH MEASUREMENT

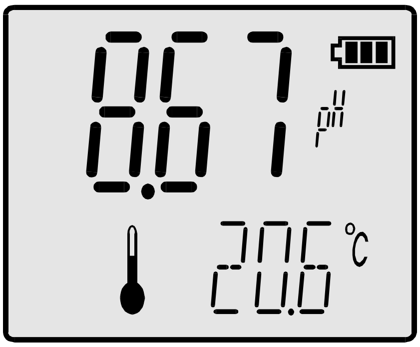
Before starting measurement, prepare the meter (chapter 7) and the pH electrode (chapter 8) for work. Good condition of the electrode is the most important factor of accurate measurements.

10.1. Measurement with automatic temperature compensation

During measurements with automatic temperature compensation the meter co-operates with the temperature probe and measures the temperature of the solution simultaneously with pH. The measured temperature is taken into consideration during compensation.
In case of measurement with automatic temperature compensation:

- join the temperature probe and the combination pH electrode to the appropriate connectors on the meter (pic.1);
- if the electrode is not calibrated or has already been in use for some time it is advisable to calibrate it (chapter 8);
- insert the electrode and the temperature probe to the measured solution. During measurements in vessels do not touch the bottom and the walls with the electrode. It is advisable to use an electrode stand;
- turn the meter on by pressing the ON OFF button;
- choose the pH measurement mode according to the chapter 6.1;
- after stabilisation read the result (pic. 10)

Accurate laboratory measurements require using of magnetic stirrers.



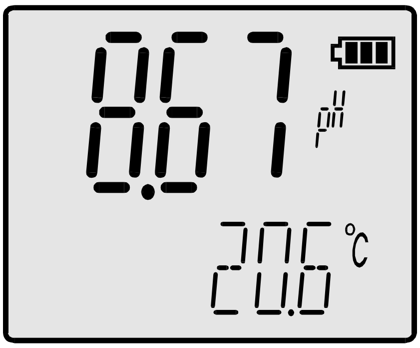
Pic. 10

NOTE: exceeding of the range of temperature compensation is indicated by blinking of the pH reading and the symbol.

10.2. Measurements with manual temperature compensation

Disconnecting the temperature probe switches the meter to the manual temperature compensation mode (the symbol next to the temperature reading disappears).
Measurement with manual temperature compensation is similar to measurement with ATC, the difference is that in manual compensation the meter takes into consideration the value of the temperature introduced by the user instead of the temperature measured with the temperature probe.
Manual compensation may be used during work in stable conditions e.g. during pH measurements in the laboratory, especially with use of a thermostat, or when the temperature probe is broken.
During measurement with manual temperature compensation:

- switch the meter on using the button;
- insert the pH electrode to the vessel with the measured solution, if the electrode wasn't calibrated or was used for a long time, calibrate it (chapter 8). During measurements in a vessel do not touch the bottom and the walls with the electrode. It is advisable to use an electrode stand;
- measure a temperature of measured solutions using laboratory thermometer;
- enter the temperature value of measured solution for manual compensation according to the point 6.3.1;
- choose the pH measuring function according to the chapter 6.1;
- wait till the value stabilises and read the result (Pic. 11).



Pic. 11

11. NOTICES ABOUT THE TEMPERATURE COMPENSATION AND INTERPRETATION OF pH MEASUREMENTS RESULTS

The **CPC-411** pH/conductivity meter has an automatic temperature compensation, which enables eliminating errors resulting from affecting the electrode characteristics by temperature changes. The pH meter is an mV meter which displays voltage counted to pH. In constant temperature one pH unit corresponds to constant mV value. In 20 ^{0}C it is 58.17 mV. The value of mV per one pH unit **changes with the temperature change,** what is taken into consideration in the formula for “k coefficient” of the pH electrode:

$$\mathbf{k=0.198423\ T}$$

This coefficient is connected with the slope of the electrode’s characteristic and not with the measured solution. Temperature compensation doesn’t consider changes of the pH value of the solution caused by the temperature. Usually these are slight changes, however in e.g. pure water they tend to be significant. Values of solutions, which tend to be affected by the temperature changes, should be compared in the same temperature. Sometimes the results are unstable, which is connected with the quality of the electrode. **Unstable measurement results, slow drifting of the result or very long time of stabilisation are usually caused by clogged junction, contaminated or broken electrode.** It often happens in case of choosing kind of electrode inappropriate for the measured solution.

Putting the electrode into distilled water for a few hours or placing it in water with detergent may eliminate such problems, especially if measurements were made in solutions with deposits, fats or oils. The electrode which hasn’t been used for a long time, may have the junction clogged by KCl crystals, what may be removed by placing the electrode in distilled water. Heavily contaminated electrode may be cleaned in chloroform and deposits of iron in 2N HCl.

Depending on the kind of measured solution or substance, proper kind of electrode should be chosen. They differ one from another with shape, membrane’s look, kind of junction and body. Electrode for heavily polluted sewage is different than that for clean water, meat or soil. Using unsuitable electrode may cause its damage and make measurements impossible.

Results of multiple pH measurements of the same solution with stabile temperature may differ one from another. When analysing this situation, the factors given below should be taken into consideration.:

- the differences may occur because of using electrode of not very good quality;
- the result is treated as stabilised too soon (the time of stabilisation of an average-quality electrode is about 40 s.);
- the measured solution may not be homogeneous and without use of the electromagnetic stirrer the results won't be equal;
- during measurements of sewage the result may be changed by chemical reactions.

Slight differences of the results are connected with the accuracy of the meter. The accuracy of **CPC-411** is ±0,01 pH, ±1 digit, what practically means that in extreme conditions results of two measurements of the same solution may differ in ±0,05 pH. This is an acceptable error, because one result has error which totals to – 0.02 and the second one comes to + 0,02 pH. Expression ±1 digit in the technical data takes into consideration another possible difference which arises because of so-called discretisation error – number of digits displayed on the LCD.
Sometimes the accuracy of calibration is checked in another buffer solution. When performing two-point calibration in 7,00 pH and 4,00 pH buffer solutions and checking the accuracy of such calibration in 10,00 pH buffer, in some cases the result may come to 9,90 pH or 10,10 pH. Such difference is possible when the characteristic of the electrode isn't symmetrical to 7 pH.
Using three-point calibration in neutral, alkali and acidic buffer solutions may prevent such a situation.

III. CONDUCTIVITY MEASUREMENT

12. BASIC INFORMATION ABOUT THE CONDUCTIVITY MEASUREMENT

The conductivity measurement is based on applying electric current with a proper voltage and frequency to the measured solution. In **CPC-411** the voltage comes to several dozens of mV and the frequency depends on the measuring range and may vary from 1 kHz up to 12 kHz. The electric current value is dependent on the kind of the measured liquid, its concentration and temperature. The conductivity result indirectly informs about the salt concentration in the measured liquid – when it increases, the conductivity rises (KCl, NaCl). However, this dependence doesn't concern all of the solutions. In some of them, after overdrawing certain salinity value the conductivity starts decreasing. Temperature has also a great influence on the results of conductivity measurement, which increases together with the temperature rise.

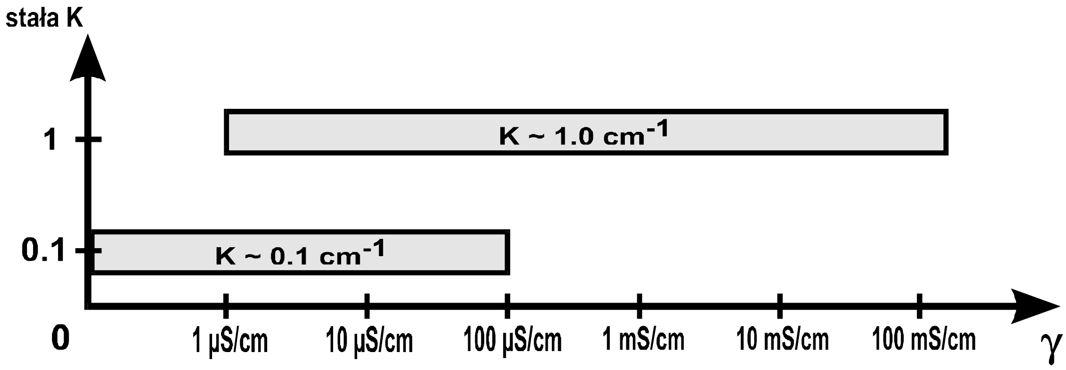
The electrodes' surface and the distance between them have decisive influence on the K constant value of the cell affecting accuracy of the measurement. Depending on the measured conductivity value cells with K constant = 0.05 cm^{-1} up to 1.500 cm^{-1} are used. During measurement the meter multiplies the measured value by the K constant introduced to the meter's memory and displays the result in units of conductivity (µS/cm or mS/cm). Next to the result a shortened symbol of the unit is displayed (µS or mS). The conductivity is changing together with temperature and salts concentration. In order to enable comparing of the results, the measured value is counted by the meter to the value which corresponds to measurement in 25 ^{0}C. Measurement in this temperature is most accurate. In other temperatures there is temperature compensation used, which means that the meter takes the currently measured temperature and α coefficient into consideration. This coefficient describes how much the result changes by 1 ^{0}C of the temperature change. **The α coefficient in this meter is constant and amounts to 2% / ^{o}C**. This is the closest value to that of most of the salts in 25°C. For example if measurements are made in liquid of temperature coming to 30 ^{0}C, the result change will total up to 5 x 2% = 10%.

The conversion is made automatically and this change is counted into the result. The conductivity measurement should always be treated as burdened with a certain error, which depends on the conductivity cell (its linearity) and temperature. When measurements are not made in the reference temperature, the error is dependent mainly on the α coefficient, which is affected by the temperature and concentration changes.

13. CHOICE AND MAINTENANCE OF THE CONDUCTIVITY CELL

13.1. Choosing the conductivity cell

The conductivity measuring range in **CPC-411** meter is 0 – 100 mS/cm. The meter co-operates with conductivity cells with K constant = 0.050 ÷ 1.500 cm^{-1} and BNC-50 connector. Depending on the required measuring range it is necessary to choose appropriate cell with K constant which enables obtaining accurate results. Beyond the range the cell looses its linearity and the results have greater error. Accurate measurements in the whole range are possible with use of 2 different conductivity cells.
In the range 1 – 100 mS/cm the standard conductivity cell with K constant =1 cm^{-1} should be used.
For measurements of ultra pure water with conductivity below 1 µS/cm a cell with K constant = 0.1 cm^{-1} should be used.
Depending on the expected measuring range, choose the appropriate cell using the chart below (Pic. 12).



Pic. 12 Dependence between the measuring range and the K constant of applied conductivity cells.

13.2. The conductivity cell maintenance

In order to receive stable results, it is advisable to store the cell in water for a few hours before the measurement, this is especially required in case of distilled water measurements.
The conductivity cell maintenance consists mainly in accurate washing the inside of the measuring cell with distilled water. The platinum electrodes must not be cleaned mechanically, because this results in rubbing off the platinum layer, what can cause decreasing of accuracy, lowering of stability and changing of the K constant.
Measurements of liquids with oils and heavy-sediment content may cause platinum contamination, make the measurement impossible and irreparably damage the electrodes. In case of fat content in the measured liquids it is possible to clean the electrodes by immersing the cell in acetone, chloroform, fourhydrofuran or detergent.
Certain norms propose universal liquid for cleaning cells. This is a mixture of equal parts of isopropyl alcohol, ethyl ether and hydrochloric acid, diluted with water in 1:1 ratio.
Breaking of the measuring cell hinders any further measurements due to significant change of the K constant, unstable results and increase of the dependence of the result on the position of the cell in the measuring vessel.
The cell should be immersed in such a way for the solution to fill it up and not to include any air bubbles (single bubbles or silver coating). It is essential for obtaining accurate results of measurements. The best way is to immerse the cell, make a few vertical moves and thus to remove air bubbles through holes in the upper part of the cell. If the air bubbles appear each time after the cell has been immersed and they are difficult to remove, it is advisable to immerse the cell in a water – washing up liquid mixture, what will lower the surface tension and disable air bubbles to stick to the surface of the cell walls or electrodes. After such action the cell should be washed accurately in distilled water.

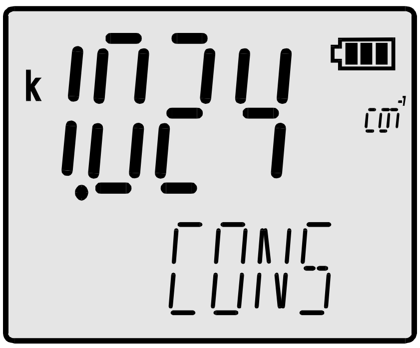
14. CALIBRATION OF THE CONDUCTIVITY CELL

Characteristic feature of every conductivity cell is its K constant. Before displaying the result on the display the value is multiplied by the K constant value. The value of the K constant depends on the size of the electrodes' surface and the distance between them. If the user keeps the cell clean, the K constant does not change. In case of contamination of the surface of the electrodes, the K constant will change.
Calibration may be performed without the sample solution, by entering the value of the K constant of the cell given by the manufacturer to the meter's memory (we recommend this kind of calibration) or with use of standard solution with known conductivity, to determine the K constant.
The K constant is precisely determined by the cell manufacturer and using this value will be the most reliable.
In case of calibration performed by the user, fresh, accurately prepared standard solution is required. Additionally it has to be accurately thermostatic to 25^{0}C. If the conditions won't be kept the calibration may be burdened with error.

14.1. Calibration without the standard solution

The meter has a possibility of calibration without the use of standard solution. For such calibration, it is necessary to know the K constant of the conductivity cell. This value may be given by the cell manufacturer or may be determined using the **CPC-411** meter after calibrating it in the standard solution.
In order to calibrate:

- in the conductivity measuring mode press the button till the moment of displaying the CONS symbol in the bottom row and the **k** symbols and the value of the K constant introduced earlier in the upper row.
- with the , buttons enter the value of the K constant;
- return to the measuring mode by pressing and holding the button.



Pic. 13

14.2. Calibration with use of standard solution

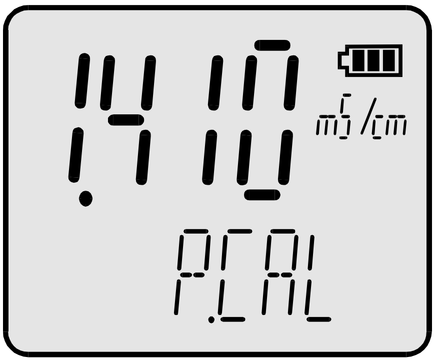
The meter enables one-point calibration in the freely chosen standard solution, to determine the K constant of the cell. In order to decrease the error, it is recommended to use solutions with value close to the estimated value of measurement. It is required to use standard solutions of a high quality.

14.2.1. Entering the standard solution value

To enter the standard solurion value:
choose the measurement unit according to the point 6.2;

- in the measurement mode press the FUNCTION button until the P.CAL symbol displays in the bottom row and the upper row displays the current calibration point value pic. 8);
- enter new standard solution value with the ↙, ↗ buttons;

press and hold the FUNCTION button to return to the measurement mode.



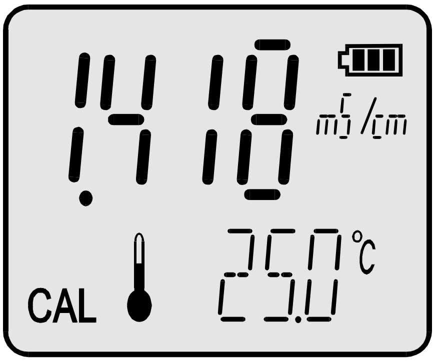
Pic. 14

14.2.2. Calibration without the temperature compensation

Accurate calibration should be processed without the temperature compensation. The sample solution should be brought to 25°C. It is possible to use the temperature probe for controlling.

In order to calibrate, follow the steps:

- connect the conductivity cell and the temperature probe to the meter;
- enter the standard solution value (point 14.2.1) immerse both probes in the standard solution, hold the conductivity cell at least 1 cm away from the bottom and the walls of the vessel. The measuring cell should be filled with the measured solution, there shouldn't be any air bubbles and the electrodes should be evenly moistened*;
- measure the temperature of the solution and bring it to 25 °C;
- in the conductivity measuring mode press and hold the CAL button till the **CAL** symbol displays on the screen (Pic.12);
- after the value stabilises the **P1** symbol (calibration point) will be displayed. Press the CAL button. Blinking of the reading signalises recording the calibration value, at the same time the measuremet value will be adjusted to the applied standard value. If the applied standard value is different then the value stored in the memory, the meter does not recognise it or the cell connected with the meter is broken, the Err symbol will display.
- return to the measuring mode by pressing the FUNCTION button.



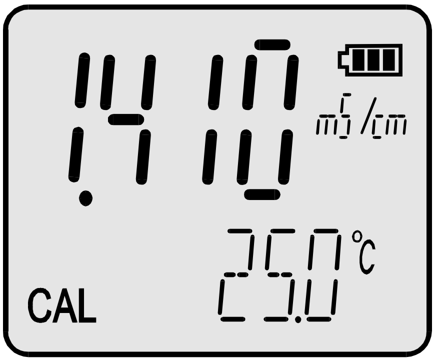
Pic. 15

The meter is calibrated and ready to work.

14.2.3. Calibration with manual temperature compensation

In order to calibrate the meter:

- turn the meter on with the button;
- enter the standard solution value (point 14.2.1);
- disconnect the temperature probe (the symbol disappears);
- enter the 25°C value with the , buttons;
- immerse the conductivity cell in the sample solution and hold it at least 1cm away from the bottom and the walls of the vessel. The measuring cell should be filled with the sample solution and shouldn't include any air bubbles, the electrode's surface should be evenly moistened*;
- measure the temperature of the sample solution with lab thermometer and bring it to 25°C;
- in the conductivity measuring mode press and hold the button till displaying the **CAL** symbol on the screen (Pic.13);
- after the value stabilises the **P1** symbol (calibration point) will be displayed. Press the button. Blinking of the reading signalises recording the calibration value, at the same time the measuremet value will be adjusted to the applied standard value. If the applied standard value is different then the value stored in the memory, the meter does not recognise it or the cell connected with the meter is broken, the Err symbol will display;
- return to the measuring mode by pressing the button.



Pic. 16

The meter is calibrated and ready to work.

* - air bubbles may be removed by moving the immersed cell. In order to make moistening of the electrodes easier, it is recommended to immerse the cell in distilled water with washing-up liquid, and than wash it in distilled water.

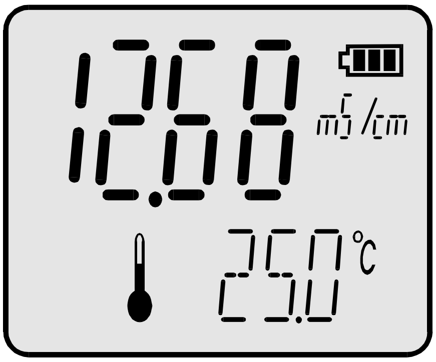
15. CONDUCTIVITY MEASUREMENT

15.1. Conductivity measurement without temperature compensation

Accurate conductivity measurement should be made without the temperature compensation. The measured solution should be brought to 25 °C. It is possible to use the temperature probe for controlling.

In order to make a measurement:
- connect the conductivity cell and the temperature probe to the connectors **F1** and **t** respectively (pic.1);
- turn the meter on with the 

button;
- choose the conductivity measuring mode according to the subchapter 6.1;
- if the conductivity cell has not been calibrated earlier calibrate it according to the chapter 14;
- place both probes in the measured solution, the conductivity cell cannot touch the walls and the bottom. The measuring cell should be filled with the sample solution and should not include any air bubbles, the electrode's surface should be evenly moistened*;
- bring the temperature of the measured solution to 25 °C;
- read the result after it has stabilised (pic. 17).

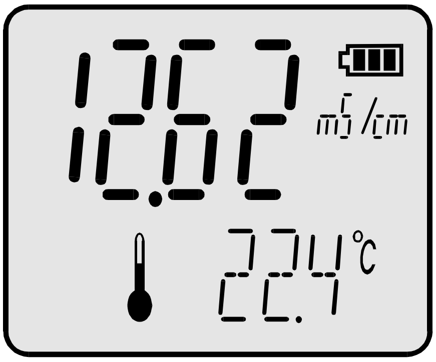


Pic. 17

* - air bubbles may be removed by moving the immersed cell. In order to make moistening of the electrodes easier, it is recommended to immerse the cell in distilled water with washing-up liquid, and than wash it in distilled water.

15.2. Conductivity measurement with automatic temperature compensation

In case of measurement with automatic temperature compensation:
- connect the conductivity cell and the temperature probe to the connectors **F1** and **t** respectively (pic.1);
- turn the meter on with the  button;
- choose the conductivity measurement unit according to the subchapter 6.1;
- if the conductivity cell has not been calibrated earlier, calibrate it according to the chapter 14;
- place both probes in the measured solution, the conductivity cell cannot touch the walls and the bottom. The measuring cell should be filled with the sample solution and should not include any air bubbles, the electrode's surface should be evenly moistened*;
- wait till the result stabilises and read it (pic. 18).



Pic. 18

Note: in case of exceeding the range of temperature compensation the conductivity reading and the  symbol start blinking.

* - air bubbles may be removed by moving the immersed cell. In order to make moistening of the electrodes easier, it is recommended to immerse the cell in distilled water with washing-up liquid, and than wash it in distilled water.

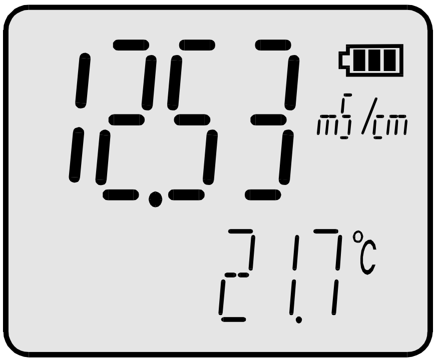
15.3. Conductivity measurement with manual temperature compensation

The measurement with manual temperature compensation may be made in stable work conditions, e.g. during measurements in laboratory, especially with use of thermostat, or in case of the temperature probe damage. Disconnecting the temperature probe switches the meter to manual temperature compensation.

In case of measurement with manual temperature compensation:

- connect the conductivity cell to the **F1** connector (pic. 2);
- disconnect the temperature probe;
- turn the meter on with the 

 button;
- choose the conductivity measurement unit according to the subchapter 6.1;
- if the conductivity cell has not been calibrated earlier, calibrate it according to the chapter 14;
- measure the temperature of the solution with thermometer;
- enter the measured temperature value for manual compensation according to the point 6.2.1 ;
- place the cell in the measured solution, it canot touch the walls and the bottom. The measuring cell should be filled with the sample solution and shouldn’t include any air bubbles, the electrode’s surface should be evenly moistened*;
- after stabilisation read the result (pic. 19).



Pic. 19

* - air bubbles may be removed by moving the immersed cell. In order to make moistening of the electrodes easier, it is recommended to immerse the cell in distilled water with washing-up liquid, and than wash it in distilled water.

15.4. Conductivity measurement in honey

The unit of conductivity of honey given by literary sources is 10^{-4}S/cm, which means that one unit of conductivity of honey is equal 100 µS/cm. If the meter indicates 250 µS/cm, it will inform about 2,5 units of honey conuctivity. If the readout is equal 1,5 mS/cm, it will be equal 15 units of the conductivity of honey. The table below contains conductivity values typical for different types of honey.

Table 1.

Honey	Conductivity x 10^{-4}S/cm	The meter's indication
Fir honeydew	>10	>1mS/cm
Leaf honeydew	~9	~900 µS/cm
Honeydew-nectar	~8	~800 µS/cm
Chestnut honey	>10	>1mS/cm
Linden honey	6,8 ÷ 7,8	680 ÷ 780 µS/cm
Heath honey	2,9 ÷ 8,0	290 ÷ 800 µS/cm
Golden rod honey	~5,8	~580 µS/cm
Buckwheat honey	~4,9	~490 µS/cm
Borage honey	~1,27	~127 µS/cm

15.5. Preparation of the measurement sample

Because of honey's density, it is necessary to prepare water - honey solution for the measurement. To do it, dilute 12g of honey in 50 ml of distilled water. Next, choose the unit (the S/cm HONEY symbols, next to the Cnd symbol, point 6.1) and make the measurement according to the chapter 15.

16. SALINITY MEASUREMENT

Salts and minerals dissolved in natural water influence the conductivity, which in principle is proportional to the quantity of dissolved substances. This dependence enables, after certain calculations, to determine the salinity of the measured solution in concentration units (g/l or %), or to determine the TDS (Total Dissolved Solids). The received values are always approximate and the total accuracy depends on the way of making the calculations, concentration of the measured solution and its temperature. In most salinity meters a simplification is used, that dependence between conductivity and salinity in the solution is linear in the whole measuring range. Usually a 0.5 coefficient is used, the conductivity result in mS/cm is multiplied by this coefficient and the result of salinity is received in g/l, e.g., if the conductivity value is 2 mS/cm the salinity is 1g/l. In practice the dependence between conductivity and salinity isn't linear and the conversion coefficient is changing together with the concentration and temperature. Table 2 shows the dependence between conductivity and actual salinity of NaCl solution in temperature 25 ^{0}C and values of salinity counted for constant coefficient 0.5. This comparison shows that using a constant coefficient for greater concentrations introduces significant error.

Table 2.

Conductivity (mS/cm)	Actual salinity (g/l)	Salinity (g/l) Counted for coefficient = 0.5	Error (%) by using the coefficient = 0.5
1.00	0.495	0.500	0.01
2.00	1.006	1.000	0.60
4.00	1.976	2.000	1.21
10.00	5.400	5.000	7.40
30.00	18.174	15.000	17.46

In CPC-411 microcontroller takes into consideration the actual dependence between the conductivity and salinity what greatly reduces the error.

16.1. Salinity measurement with conversion to NaCl content.

The salinity measurement with conversion to NaCl content shyould be done in the following way:

- choose the measuring unit (no symbol) as for salinity measurement according to the chapter 6.2;
- next act exactly as with the conductivity measurement (chapter 15);
- after stabilisation of the reading read the measurement result.

Note: next to the reading the unit symbol on turn with the symbol displays.

16.2. Salinity measurement with conversion to TDS

The meter enables simplified way of determining the Total Dissolved Solids (TDS) content. For calculations the constant coefficient is used ($W_{TDS} = 0.5$). The measurement of salinity with conversion to TDS should be done as follows :

-- choose the measurement of salinity with conversion to TDS according to the subchapter 6.1;

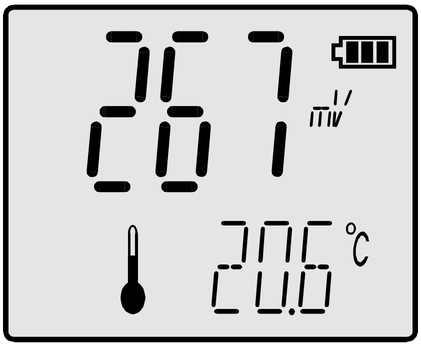
- act as during the conductivity measurement (chapter 15).
- after it has stabilised, read the result in g/l.

Note: next to the reading the unit symbol on turn with the symbol displays.

IV. REDOX POTENTIAL AND TEMPERATURE MEASUREMENT

17. REDOX POTENTIAL MEASUREMENT

CPC-411 enables mV measurement. The measurement may be made with use of special redox electrode or during titration. The readout is possible after choosing the mV measurement mode (chapter 6.1).



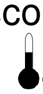
Pic. 20

18. TEMPERATURE MEASUREMENT

The temperature measurement is made in the following way:

- connect the temperature probe to the Chinch connector;
- by pressing the  button switch the meter on;
- choose the temperature measuring mode using the  button;
- put the temperature probe to the measured solution;
- wait till the value stabilises and read the result.

The meter co-operates with platinum resistor sensor PT-1000 and the final accuracy of the temperature measurement depends on its class.

NOTE: break in the circuit or disconnecting of the temperature probe is signalised by disappearing of the . In such case the meter shows the temperature value introduced by the user for manual temperature compensation. Blinking -50℃ value during measurement in positive temperatures informs about short circuit in the temperature probe.

V. OTHER

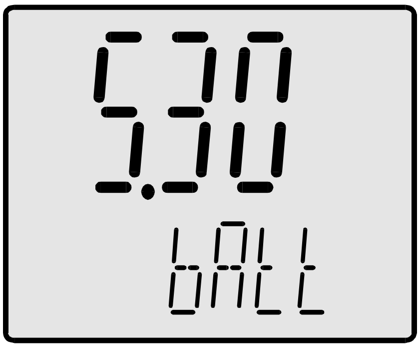
19. READOUT OF THE SOFTWARE VERSION NUMBER

In order to check the software version number turn the meter off and next, holding the 

button, turn the meter on by pressing the 

button. Instead of the display test, the screen as in the picture below will appear (Pic. 21). In the upper row the software version will appear and in the lower row a type of internal power supply, to which the meter has been adjusted:

Accu - internally powered by two rechargeable R6/AA batteries;
bAtt - internally powered by two standard R6/AA batteries.



Pic. 21

After about 1.5 s. the meter enters the measurement mode.

20. POWER SOURCE AND CHANGING THE BATTERY

The meter is powered by 9V battery or 12V stabilised power adapter. The adapter should be joined with the **P** connector (Pic.1). Connecting the power adapter disconnects the battery and is signalised by the symbol.

The symbol informs about the battery condition. Flashing of the symbol informs that the battery should be changed. In order to do so, it is necessary to undo two screws in the lower wall of the meter, pull out the whole wall and replace the battery.

The next thing is to put the new battery into the meter and mount the wall.

The wall has a sealing ring at the edge. While closing the meter, it is very important to pay attention if the ring is put inside the housing in the whole perimeter. Next, do the screws till the moment of resistance (not too hard). Leaving the wall improperly screwed may cause the meter’s inundation, which is not repaired under the warranty conditions.

21. TECHNICAL DATA

pH MEASUREMENT:

range	resolution	accuracy (±1 digit)
0.00 ÷ 14.00 pH	0.01 pH	±0.01 pH

Input impedance: $>10^{12}\ \Omega$
Temperature compensation: automatic
Range of compensation: -5.0 ÷ 110.0 ^{o}C
pH electrode calibration: automatic, in 1 ÷ 3 points
Thermal stability of zero: 0.001pH/^{o}C

REDOX POTENTIAL (mV) MEASUREMENT:

range	resolution	accuracy (±1 digit)
-1999 ÷ 1999 mV	1 mV	±1 mV

CONDUCTIVITY MEASUREMENT:

ranges	resolution	accuracy * (±1 digit)	frequency
0.000 ÷ 199.9 µS/cm	0.1 µS/cm	±0.25 %	1 kHz
200 ÷ 1999 µS/cm	1 µS/cm	±0.25 %	1.6 kHz
2.00 ÷ 19.99 mS/cm	0.01 mS/cm	±0.25 %	4.6 kHz
20.0 ÷ 100.0 mS/cm	0.1 mS/cm	±0.25 %	12 kHz

* accuracy given for the upper value of the range.

Ranges of frequency changes were given for constant K = 1. For other values of the K constant the values will change proportionally to changes of this constant.

Temperature compensation: manual/automatic
Compensation range: -5.0 ÷ 70.0 ^{o}C
K constant range: 0.05 ÷ 1.500 cm^{-1}
α coefficient: constant 2 %/ ^{o}C
W_{TDS} coefficient: constant 0.5
Cell calibration: one-point

1. by introducing the K constant of the cell
2. with use of calibration solution

TEMPERATURE MEASUREMENT:

range	resolution	accuracy* (±1 digit)
- 50.0 ÷ 199.9 °C	0.1 °C	±0.1 °C

* accuracy of the meter. Final accuracy of the measurement depends on accuracy of applied PT-1000 probe

Temperature probe: Pt-1000 platinum resistor

Accuracy of the probe in range 0 ÷ 100 °C:
for Pt-1000b resistor: ±0.9 °C
for Pt-1000$^1/_3$B resistor: ±0.4 °C

OTHER:

OPERATING TEMPERATURE: -5 ÷ 45 °C
POWER: 1. 9V battery type 6F22
2. power adapter 12V
POWER CONSUMPTION: 27 mW
DISPLAY: LCD 55 x 45 mm
DIMENSIONS: 149 x 82 x 22 mm
WEIGHT: 220 g (with battery)

22. EQUIPMENT

Standard set:
1. glass combination pH electrode;
2. conductivity cell;
3. Pt-1000B temperature probe (standard);
4. plastic case for the meter, electrode and temperature sensor;
5. user's manual with warranty.

Additional equipment:
1. 12V/100mA stabilised power adapter;
2. Pt-1000 1/3B temperature probe of higher accuracy.

W A R R A N T Y

The “ELMETRON” company gives 24 months of warranty for the **CPC-411** pH/conductivity meter number

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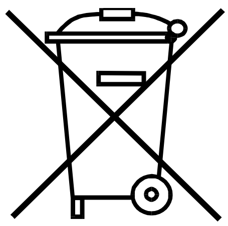
The electrode and the cell have 12-month warranty.

In case of damage the manufacturer will repair the meter within 14 days from the day of delivery.
The warranty doesn’t cover the damages caused by usage not in conformity with the users manual, using wrong power adapter, mechanical damages and damages caused by repairs made by unauthorised persons.

NOTE: Before sending the meter to us please contact the firm by phone.

When sending the meter, the pH electrode, the conductivity cell, the temperature probe and the power adapter should be also included.

Date of production...........................
Date of sale.....................................
Date of expiry..................................



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