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Preliminary
Instruction Manual
for
PHM71 Mk2
Acid-Base Analyzer

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SECTION A - SPECIFICATIONS

THE PHM71 Mk2

RANGE

pH:

Normal: 0 to 14
Expanded: 6.6 to 8.0 P_{O_2} :With the PHA934 P_{O_2} Module mounted:
0 to 160 mm Hg
0 to 800 mm Hg P_{CO_2} :With the PHA935 P_{CO_2} Module mounted:
0 to 80 mm Hg
0 to 160 mm Hg

ELECTRICAL ZERO POINT

7.383 pH units

pH ELECTRODE SENSITIVITY
COMPENSATION

Uncalibrated. Mark for 100% (37°C)

pH ADJUSTMENT CONTROL

Adjustable from 0 to 130 mV
Not calibrated. 6-turn gear with reverse vernier
6:1.

METER

160 mm individually calibrated scale (linearity $\pm 0.15\%$),
mirror-backed with knife-edge pointer; taut-band-
suspended moving coil.

ELECTRODE INPUT TERMINALS

3 electrode input terminals for combined pH, P_{O_2} and
 P_{CO_2} electrodes, respectively.

RECORDER OUTPUTS

REC.1

2-4 constant
pH

		P_{CO_2}	P_{O_2}
VOLTAGE (pins 4 and 5)	-500 mV/pH	-500 mV/100 mm Hg	-500 mV/100 mm Hg
CURRENT (pins 1 and 5)	-100 μ A/pH	-100 μ A/decade -100 μ A/100 mm Hg	-100 μ A/100 mm Hg
ZERO at	pH 6.6 or pH 0	200 mm Hg or 0 mm Hg	0 mm Hg

The REC.1 output socket accepts a 5-pole EUROPEAN STANDARD connection plug for radio,
DIN 41524 - e.g., the 8-7506 PREH Plug.

The plug must be connected as follows:

- Pin 1 -100 μ A/unit
- Pin 2 Input to meter
- Pin 3 Ground
- Pin 4 -500 mV/unit
- Pin 5 Recorder 0 V

Pco₂ LOG-LIN SWITCH

Pin 1 only

REC.2

VOLTAGE	100 mV for full scale deflection, independent of scale to be used.
OUTPUT IMPEDANCE	150 to 200 Ω , dependent on range.

The REC.2 output socket accepts a 5-pole EUROPEAN STANDARD connection plug for radio, DIN 4152 - e.g., the 8-6082 PREH Plug.

The plug must be connected as follows:

- Pin 5 Ground
- Pins 1 and 3 Terminals of external instrument
- Pins 2 and 4 Not connected

OPERATING TEMPERATURE

10-40°C ambient

POWER REQUIREMENTS

115 V \pm 15%, 47.5-62.5 Hz, 0.10 A
220 V \pm 15%, 47.5-62.5 Hz, 0.015 A

DIMENSIONS AND WEIGHT

Height: 230 mm (9 1/16")
Width: 410 mm (16 1/8")
Depth: 190 mm (7 1/2")
Weight: 5.7 kilos (13 lbs.)

FINISH

Chemically resistant paint on aluminium.

	pH		Pco ₂		Po ₂	
READING	0 to 14 pH	6.6 to 8.0 pH	8 to 80 mm Hg	0 to 160 mm Hg	0 to 160 mm Hg	0 to 800 mm Hg
	Direct reading	Direct reading	Direct reading	Direct reading	Direct reading	Multiply reading 0 to 80 by 10
SMALLEST SCALE DIVISION	0.1 pH	0.01 pH	1 mm Hg	1 mm Hg	1 mm Hg	10 mm Hg
READABILITY	±0.01 pH	±0.001 pH	±0.1 mm Hg	±0.2 mm Hg	±0.2 mm Hg	±1 mm Hg
RELATIVE ACCURACY (2 point adjust- ment)	±0.02 pH	±0.002 pH	±0.12 mm Hg	±0.25 mm Hg	±0.25 mm Hg	±1.2 mm Hg
DRIFT	< 0.004 pH/°C	< 0.0007 pH/°C	0.3% of reading per °C			
	< 0.002 pH/24 h. non-cumu- lative	< 0.002 pH/24 h. non-cumu- lative				
INPUT IMPEDANCE	> 10 ¹² Ω		> 10 ¹² Ω			
INPUT CURRENT	< 10 ⁻¹² A		< 10 ⁻¹² A			

FHA934 Po₂ Module

RANGE:	0 to 160 mm Hg 0 to 800 mm Hg
CONTROLS:	
ZERO	-7 to +700 × 10 ⁻¹²
RANGE and ADJUSTMENT	10 ⁻¹² to 10 ⁻¹⁰ A/mm Hg
POLARIZING VOLTAGE	530 ± 50 mV
MERCURY CELL	Mallory RM-IR or equivalent type
OPERATING TEMPERATURE	10 to 40°C ambient
DIMENSIONS and WEIGHT:	
H x W x D	192 x 63 x 130 mm (7 1/2" x 2 1/2" x 5 1/2")
Weight	~ 1/2 kg (1 lb.)

FHA935 Pco₂ Module

RANGE:	0 to 80 mm Hg 0 to 160 mm Hg
CONTROLS:	
GAS 1 (Electrical Zero Point)	20 to 100 mm Hg
SENSITIVITY	Uncalibrated. Mark for 100% (37°C)
ADJUSTMENT Control	Adjustable from 0 to 130 mV Not calibrated. 6-turn gear with reverse vernier 6:1
OPERATING TEMPERATURE:	10 to 40°C ambient
DIMENSIONS and WEIGHT:	
H x W x D	192 x 63 x 130 mm (7 1/2" x 2 1/2" x 5 1/2")
Weight	~ 1/2 kg (1 lb.)

SECTION B - ACCESSORIES

Qty.	type	code	
1	H22		electrode adapter
1	L409/10 k Ω		polarizing adapter w/1 H32 adapter
1		955-315	dust cover
1			instruction manual

Accessories available:

PHA934	Po ₂ -Module w/1 930-114 mercury cell
PHA935	Pco ₂ -Module

SECTION C - MOUNTING INSTRUCTIONS

Mounting the PHA934 Po_2 Module

- 1) Insert the 430-114 Mercury Cell in the cell holder located at the back of the Po_2 -module. The insulated pole must face the centre pin of the holder.
- 2) Remove the left-hand blank panel of the PHM71 Mk2 and insert the Po_2 -module by sliding it along the guide rails.

Mounting the PHA935 Pco_2 Module

- 1) Make sure that the small switch at the back of the Pco_2 -module is in the right position for the instrument used, i.e., PHM71 AND PHM72 means PHM71/72 Mk2 and the older PHM72, and PHM71a PHM71b-means the a and b versions of the old PHM71.
- 2) Remove the right-hand blank panel of the PHM71 Mk2 and insert the Pco_2 -module by sliding it along the guide rails.

Mounting the electrodes

The electrode terminals for the pH, the Pco_2 and the Po_2 electrodes are located on the left-hand side of the PHM71 Mk2. The terminals accept combined electrodes directly. pH and Pco_2 electrodes with separate reference electrodes may be used in conjunction with the H32 Electrode Adapter.

SECTION D - OPERATING INSTRUCTIONS

This section is based on the PHM71 Mk2 Acid-Base Analyzer with the PHA934 Po_2 Module and the PHA935 Pco_2 Module mounted. If the PHM71 Mk2 is used alone, disregard the items dealing with Po_2 and Pco_2 measurements.

Preparing the PHM71 Mk2

Check the line voltage and connect the instrument to the power line. Make sure that the POWER lamp goes on and that the pushbutton MEASURE is released. Provide proper grounding.

pH MEASUREMENTS IN BLOOD

General remarks on calibration in blood pH-measurements

- 1) The instructions below give a complete calibration and a calibration check of the pH electrode when using the expanded pH scale (pH 6.6 to 8.0).
 - a) The complete calibration should be carried out, for example, once or twice a day to ensure that the zero and the span of the Acid-Base Analyzer are in agreement with the zero and the sensitivity of the electrodes.
 - b) The calibration check should be performed several times a day to ensure that the electrodes are operative and not subject to excessive drift.

- 2) The intervals at which calibration should be made are suggested only. They should be shortened.
 - a) when extremely high accuracy is important
 - b) when new or recently assembled electrodes are used
 - c) when the electrodes have been warmed up to the measuring temperature shortly before the first calibration, or when the electrodes have been exposed to shocks (thermal, mechanical or electrical)
 - d) whenever signs of instability are observed.

Complete calibration of the pH electrode

- 1) Prepare the PHM71 Mk2 for measuring
- 2) Prepare the electrode for measuring and connect it to its terminal on the Analyzer.
- 3) Make the following settings on the Analyzer:
 - a) P_{CO_2} -pH- P_{O_2} switch to pH
 - b) RANGE switch to 6.6-8.0
- 4) Rinse the electrode.
- 5) Push button MEASURE.
- 6) Using the ADJUSTMENT knob, adjust against the S1510 Buffer to make the meter read pH = 7.383.
- 7) Rinse the electrode.
- 8) Using the SENSITIVITY knob, adjust the electrode sensitivity against the S1500 Buffer (pH = 6.841).
- 9) Release button MEASURE.
- 10) Rinse the electrode.

Calibration check of the pH-electrode

- 1) Set the P_{CO_2} -pH- P_{O_2} switch to pH.
- 2) Rinse the electrode and apply the pH 7.383 Buffer.
- 3) Push button MEASURE.
- 4) If necessary, readjust the ADJUSTMENT knob to make the meter read pH = 7.383.
- 5) Release button MEASURE.
- 6) Rinse the electrode.

Measuring pH

- 1) Calibrate the pH electrode.
- 2) Apply the blood sample to the electrode.
- 3) Set the P_{CO_2} -pH- P_{O_2} switch to pH.
- 4) Push button MEASURE, and read the pH of the blood sample when the reading has become stable.
- 5) Release button MEASURE.
- 6) Rinse the electrode.
- 7) After use, do not switch off the instrument unless the instrument is not to be used for a few days, as the power dissipated in the electronics will protect the instrument against humidity.

P_{O_2} MEASUREMENTS IN BLOOD

General remarks on calibration

- 1) The instructions below give a complete calibration and a calibration check for the P_{O_2} electrode, using the PHM71 Mk2 in conjunction with the PHA934 P_{O_2} Module.
- 2) Intervals and precautions for calibrations are the same as for the pH electrode.

Complete calibration of the P_{O_2} electrode

- 1) Mount the PHA934 P_{O_2} Module in the PHM71 Mk2 (see mounting instructions).
- 2) Prepare the PHM71 Mk2 for measuring.
- 3) Prepare the P_{O_2} electrode for measuring and connect it to its terminal on the Analyzer.
- 4) Apply an oxygen-free solution (S4150 P_{O_2} Zero Solution) to the electrode.
- 5) Make the following settings on the Analyzer:
 - a) P_{CO_2} -pH- P_{O_2} switch to P_{O_2} , 160

- b) RANGE switch to 1
- 6) Push button MEASURE.
- 7) Allow the reading to settle, then turn the ZERO knob to make the meter read 0 mm Hg.
- 8) Rinse the electrode.
- 9) Apply a sample of known P_{O_2} (generally in the range 140-160 mm Hg).
- 10) When the reading becomes stable, adjust the ADJUSTMENT knob and the RANGE knob to make the meter read the known P_{O_2} value.
- 11) Release button MEASURE.
- 12) Rinse the electrode.

Calibration check of the P_{O_2} electrode

- 1) Rinse the electrode and apply a sample of known P_{O_2} .
- 2) Set the P_{CO_2} -pH- P_{O_2} switch to P_{O_2} , 160 (or P_{O_2} , 800).
- 3) Push button MEASURE.
- 4) Check the reading and readjust the ADJUSTMENT knob, if necessary.
- 5) Release button MEASURE.
- 6) Rinse the electrode.

Measuring P_{O_2}

- 1) Calibrate the P_{O_2} electrode.
- 2) Apply the blood sample to the electrode.
- 3) Set the P_{CO_2} -pH- P_{O_2} switch to P_{O_2} , 160.
- 4) Push button MEASURE and read the P_{O_2} of the sample when the reading has become stable. (If the reading is out of range, switch to P_{O_2} , 800 and use the scale 0-80 mm Hg with a multiplier of 10.)

- 5) Release button MEASURE.
- 6) Rinse the electrode.

Pco₂ MEASUREMENTS IN BLOOD

General remarks on calibration

- 1) The instructions below give a complete calibration and a calibration check for the Pco₂ electrode, using the PHM71 Mk2 in conjunction with the PHA935 Pco₂ Module.
- 2) Intervals and precautions for calibrations are the same as for the pH electrode.
- 3) Two gases of accurately known Pco₂-values must be available. In the following, the gas with the low Pco₂ content is called Pco₂ (1), and the gas with the high Pco₂ content is called Pco₂ (2).

Complete calibration of the Pco₂ electrode

- 1) Mount the PHA935 Pco₂ Module in the PHM71 Mk2 (see mounting instructions).
- 2) Prepare the PHM71 Mk2 for measuring.
- 3) Prepare the Pco₂ electrode for measuring and connect it to its terminal on the Analyzer.
- 4) Apply Pco₂ (1) to the electrode.
- 5) Make the following settings on the Analyzer:
 - a) Pco₂-pH-Po₂ switch to Pco₂, 80.
 - b) GAS 1 to the Pco₂-value of Pco₂ (1).
- 6) Push button MEASURE.
- 7) When the reading has become stable, adjust the ADJUSTMENT knob to make the meter read the Pco₂ of Pco₂ (1).
- 8) Apply Pco₂ (2) to the electrode.
- 9) Adjust the SENSITIVITY knob to make the meter read Pco₂ (2).
- 10) Release button MEASURE.

Calibration check of the Pco₂ electrode

- 1) Set the Pco₂-pH-Po₂ switch to Pco₂, 80.
- 2) Apply Pco₂ (1) to the electrode.
- 3) Push button MEASURE.
- 4) If necessary, readjust the ADJUSTMENT knob to make the meter read Pco₂ (1).
- 5) Release button MEASURE.

Measuring Pco₂

- 1) Set the Pco₂-pH-Po₂ switch to Pco₂, 80.
- 2) Apply the blood sample to the electrode.
- 3) Push button MEASURE and read the Pco₂ of the sample when the reading has become stable (if the reading is out of range, switch to Pco₂, 160).
- 4) Release button MEASURE.
- 5) Rinse the electrode.

pH MEASUREMENTS IN GENERAL

pH measurements in general are performed similarly to pH measurements in blood, with the following modifications:

- 1) Combined electrodes can be used directly. If separate electrodes are used, secure the glass electrode plug in its terminal by means of the H32 Electrode Adapter. Insert the reference electrode plug in the adapter.
- 2) RANGE switch on the Analyzer set to 0-14, or 6.6-8.0.
- 3) Buffers selected with suitable values.

SECTION E - MAINTENANCE

LEAK button - membrane check

The LEAK button is used for a quick check on the membrane electrodes used in Po_2 and Pco_2 measurements. If it is impossible to carry out the complete calibration or a calibration check for Po_2 or Pco_2 measurements in blood as described in section D, depress the LEAK button instead. If doing so produces a notable deflection of the meter pointer, a leakage exists in or around the membrane of the electrode. The membrane must then be replaced.

BATTERY button

The BATTERY button is used only when the Analyzer is equipped with the PHA934 Po_2 Module. When pushed, the meter indicates the condition of the mercury cell built into the Po_2 Module. If the mercury cell is in good working order, the meter pointer will settle within the limits of BATT. printed on the scale. If not, replace the mercury cell.

Short routine check of the PHM71 Mk2

- 1) Connect the power cord to the power line and make sure that the POWER lamp goes on. Provide proper grounding.
- 2) Insert the H22 Electrode Adapter in the pH terminal and secure it by means of the H32 Adapter.
- 3) Interconnect the H22 Electrode Adapter and the H32 Adapter by means of the L409/10 k Ω Polarizing Adapter.
- 4) Make the following settings on the Analyzer:
 - a) Button MEASURE released
 - b) Pco_2 -pH- Po_2 switch to pH
 - c) RANGE switch to 6.6-8.0
- 5) The meter must read pH 6.600. If not, the mechanical zero point of the meter must be corrected. This is accomplished by removing the rubber plug on the front panel and adjusting the screw that is accessible through the hole.

- 6) Push button MEASURE.
- 7) Rotate the ADJUSTMENT knob to its extreme clockwise position to make the meter read $\text{pH } 7.383 \pm 0.010$.
- 8) Check that the pointer does not move when the SENSITIVITY knob is rotated. Set the SENSITIVITY knob to the black mark.
- 9) Set the RANGE switch to 0-14.
- 10) Check that the pointer settles at $\text{pH } 7.38 \pm 0.01$.
- 11) Check that the pointer does not move when the SENSITIVITY knob is rotated. Reset the SENSITIVITY knob to the black mark.
- 12) Release button MEASURE.

ELECTROSTATIC DISTURBANCES

Pronounced electrostatic fields may be present, especially in rooms where tables and/or floors are covered with plastic.

Moving fields may result from persons, particularly when wearing rubber shoes - or shirts, coats and blouses made of nylon, silk or other fabrics that accumulate static charges.

The PHM71 Mk2 Acid-Base Analyzer and its electrodes are carefully shielded to reduce disturbances from such fields during the measurements. However, when glass electrodes of the stem type are used the lower part of the glass electrode must necessarily be unshielded, thus leaving open a space between the surface of the test solution and the shield of the electrode, and electrostatic fields may move along this exposed space and cause the meter pointer to fluctuate. This can be avoided by immersing the electrode at least 25 mm into the sample which will then act as a shield.

Another disturbance may supervene if the operator, while wiping the electrodes, carries a high electrostatic voltage to the glass electrode. After this kind of disturbance, the zero point of the electrode may have shifted several tenths of a pH unit, and it may not settle again at its original value for 5 to 10 minutes. Such a disturbance can be avoided by placing a grounded metal plate (for example, stainless steel) under the pH meter and the electrode setup in such

a way that the operator must touch it while rinsing the electrodes.

Another efficient remedy is to treat tables, floors, coats, etc., with an antistatic solution.

AC VOLTAGE OF THE INSTALLATION GROUND

In some cases the installation ground may carry an ac voltage of several volts to true ground. This can disturb the functioning of the pH meter, especially if the measuring cell is connected to true ground.

One remedy is to use a cold water pipe for grounding the pH meter; another is to have the local installation ground wired separately or wired with a heavier wire.

The third and best remedy is to use the same grounding for the cell and for the pH meter - in other words, to connect the cell (shield, frame, water jacket, or metal container) to the terminal of the PHM71 Mk2 Acid-Base Analyzer.