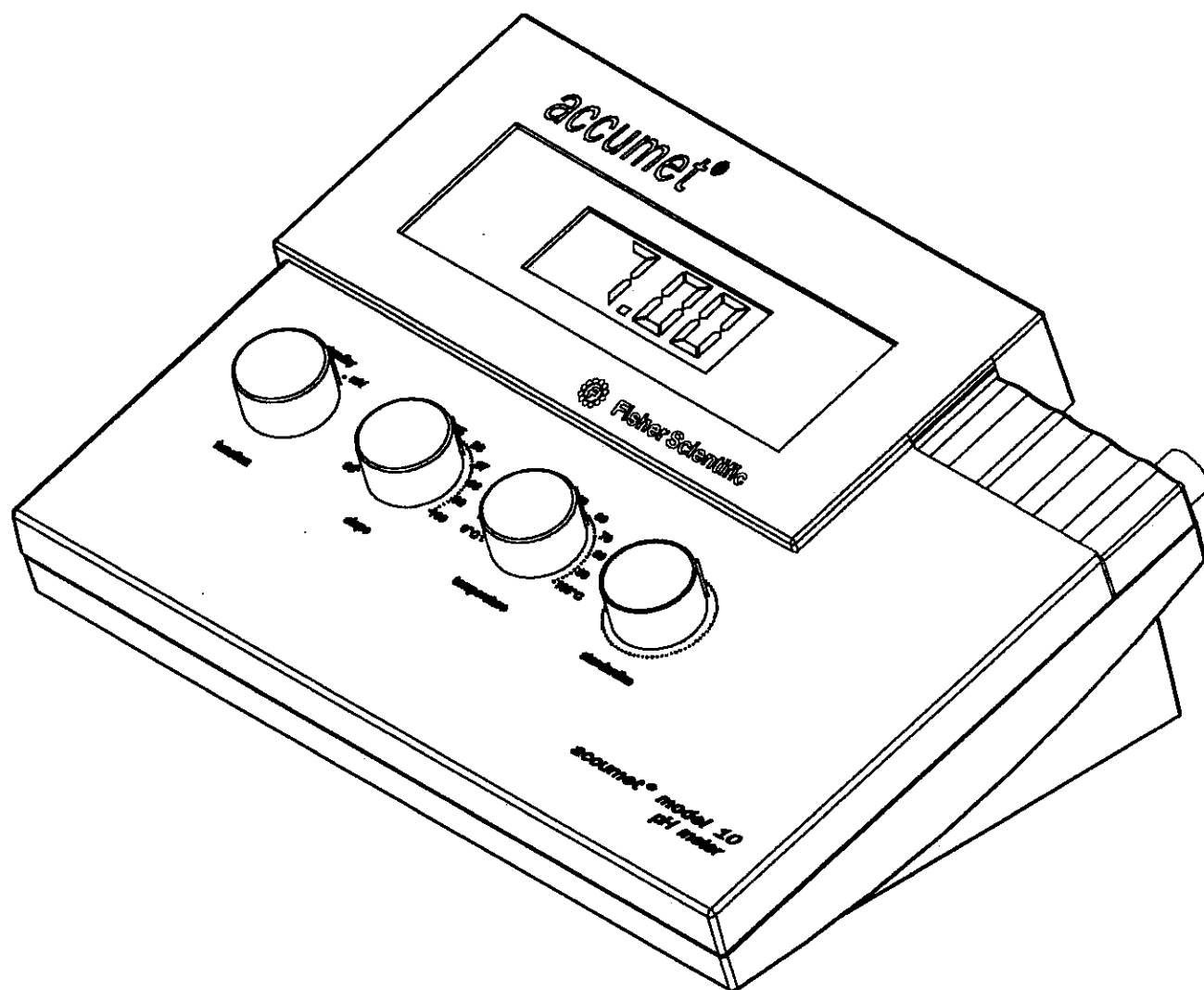


Model 10 pH/mV Meter

Operating Instructions



 **Fisher Scientific**

300025.1
REV. E

Basic pH Theory

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INTRODUCTION

The accumet® pH meter is a moderately-priced analog (Model 5) or digital (Model 10) display unit incorporating up-to-date electronics and numerous state-of-the-art control features. It therefore performs as a true general laboratory instrument, yet is ideal for classroom experimental work.

The pH meter incorporates all the necessary controls and/or connections to compensate manually for the effects of solution temperature; to correct electrode response to that predicted by Nernstian theory; to standardize the meter with buffers; and to attach a laboratory recorder. The Model 10 allows use of the temperature probe for automatic temperature compensation. The Model 5 analog display is direct-reading for pH from 0 to 14 and millivolt potential from 0 to ± 700 mV. The Model 10 digital display is direct reading from 0.00 to 14.00 pH, and 0 to ± 1999 mV. The controls are clearly marked on the front panel, and all connectors are placed across the instrument's rear panel for easy access and simplified operation.

UNPACKING

The accumet® pH Meter is shipped in a single carton containing the items listed below. Fill out and return the warranty card shipped with the pH Meter.

NOTE: *In the event that shipping damage has been observed, retain the carton and packing material intact with the unit, and file claim with the final carrier. Usually, the firm will send an inspector to ascertain liability.*

Quantity	Item
1	accumet® pH Meter
1	Electrode Support and Bracket
1	Instruction Manual
1	pH Electrode (Not provided with "A" Series)
1	Transformer

ELECTRODE SUPPORT ASSEMBLY

The electrode support holder arm is easily installed on the support base by performing the following steps:

1. Loosen the friction knob near the support bracket to ease assembly.
2. Place the hole in the base of the electrode holder arm down over the pin on the holder bracket attached to the meter base.
3. Tighten the friction knob to secure.

PERFORMANCE CHARACTERISTICS

	<i>Model 5</i>	<i>Model 10</i>
<i>Ranges:</i>		
pH	0.0 - 14.0 pH	0.00 - 14.00 pH
Millivolts	± 700 mV	± 1999 mV
<i>Resolution:</i>		
	—	0.01 pH
	—	± 1 mV
<i>Repeatability:</i>		
pH	± 0.05 pH	± 0.01 pH
Millivolts	± 5 mV	± 1 mV
<i>Relative Accuracy:</i>		
pH	± 0.1 pH	± 0.02 pH
Millivolts	± 15 mV	± 1 mV
<i>Input Impedance:</i>		
	>10 ¹² ohms	>10 ¹² ohms
<i>Stability:</i>		
	Negligible Drift on analog meter	less than ± 0.01 pH or ± 1 mV drift over 24 hour period.
<i>Temperature Compensation:</i>		
	Manual	0 to 100°C
<i>K.F. Polarizing Current:</i>		
	-10 µA	
<i>Recorder Output:</i>		
	Buffered Electrode Millivolts	
<i>Slope Control:</i>		
	90 to 102%	

SPECIFICATIONS

Power Requirements:

AC Adaptor (provided)	120 VAC 50/60 Hz
Output	12VDC @ 500 mA

Environmental Requirements:

Humidity	0 to 90% RH (non-condensing)
Temperature	+15 to +40°C (operating) -25 to +50°C (storage)

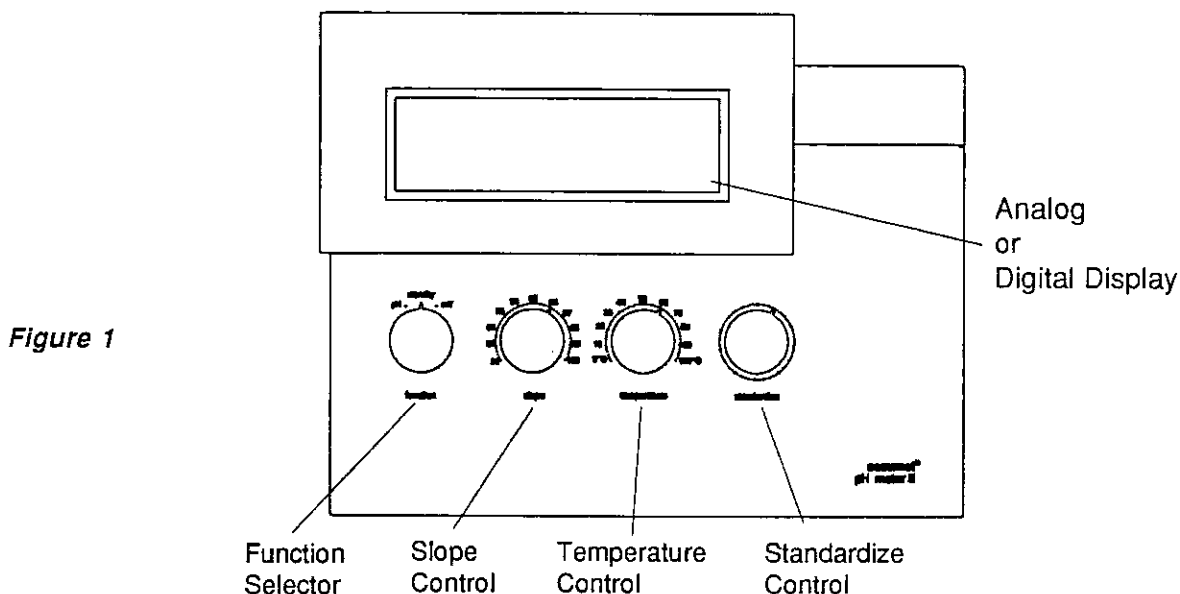
Physical Data:

Size	10-1/4" L x 8" W x 3-3/4" H
Weight	4.5 lb.

OPERATING CONTROLS

Before operating the accumet® pH meter, locate and become familiar with the function of the front panel controls, the analog or digital display, and the rear panel input jacks and output terminals.

Front Panel



ANALOG OR DIGITAL DISPLAY

The display for the accumet® pH Model 5 is an analog meter displaying 0 to 14 pH and 0 to ± 700 mV.

The display for the accumet® pH Model 10 is a Liquid Crystal Display (LCD). In pH measuring mode test results are displayed over the full 0-14 pH range, to one hundredth of a pH unit, and in the millivolt mode are displayed over a range of 0 to ± 1999 mV to 1 mV. Should the input level exceed the range of the instrument, the right most digits are blanked and a 1 or -1 will be displayed in the left most digit position. Additionally, when the mode selector is turned to **standby**, the display nominally shows zero as a reminder that the instrument is powered.

FUNCTION SELECTOR

The **function** selector is a 3-position rotary switch that places the instrument on **standby** when measurements are not being taken or selects the operating mode: **pH** for pH determination and **mV** for millivolt measurements.

SLOPE CONTROL

The **slope** control is a single-turn potentiometer used only in the pH mode to compensate for electrode efficiency. In practice, very few electrodes will exhibit the ideal Nernstian response; hence the **slope** control is used to correct the electrode response, as required by the particular electrode in use.

TEMPERATURE CONTROL

The **temperature** control is a single-turn potentiometer calibrated in two-degree increments over the range of 0° to 100°C. This control is used exclusively for manual temperature compensation in the pH measuring mode. It compensates for the temperature dependence of the electrode's response. During operation, it is set initially to the temperature of each standardizing buffer, then to that of each sample.

Note: For Model 10 Users - The temperature control is not used when you use the optional Automatic Temperature Compensating (ATC) probe.

STANDARDIZE CONTROL

The **standardize** control is a multi-turn potentiometer used in pH determinations to set the pH meter to the pH value of a buffer solution, thereby compensating for the difference in the zero potential of different electrode systems. In millivolt and redox (oxidation-reduction) measurements, the control establishes the millivolt zero reference point on the meter.

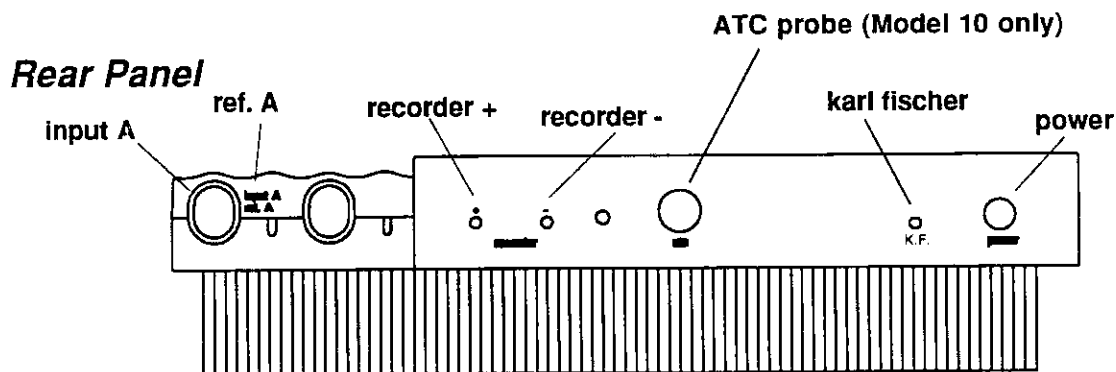


Figure 2:

INPUT A

This is a standard BNC jack that accepts the BNC plug of an indicator electrode or combination electrode. An accessory pin-jack adapter* adapts the jack to accept electrodes with pin connectors.

REF A

This is a pin-jack that accepts the pin connector of a reference electrode, if separate indicating and reference electrodes are used.

atc (Automatic Temperature Compensating probe) for Model 10 only.

The **atc** jack receives the male connector of the automatic temperature compensator probe. When this probe is plugged into the phone jack, it disconnects the manual temperature control and provides automatic temperature compensation for sample or buffer temperature.

RECORDER + -

The **recorder** jacks are standard pin jacks used to connect the recorder input leads.

POWER

The meter accepts a 5.5 mm OD x 2.1 mm power connector for an external supply of 12 VDC at 500 mA (center pin is negative, outer ring is positive).

KARL FISCHER

The **karl fischer** pin-jack (labeled **K.F.**) provides a -10 μ A polarizing current for Karl Fischer and other dead-stop titrations.

*See Accessories list on page 21.

Preliminary Procedures

Prior to making pH or millivolt determinations, the pH meter must be connected to a suitable power source and have the appropriate electrode system properly installed. The following procedures should be performed with the unit located on a flat, clean and dry surface near the power source.

Power Source Connection

The meter operates on 12 VDC

To connect the instrument to a power source, perform the following:

1. Set the **function** selector to the **standby** position.
2. Connect the transformer lead to the **power** jack on the rear panel of the pH meter.
3. Connect the transformer to an outlet of proper voltage and frequency.

Recorder

Any potentiometric recorder may be used with the pH meter by connecting the recorder to the **recorder** jacks. These jacks are standard "pin" style. The recorder output is the same value, in millivolts, as the electrode signal.

Electrode Installation

The pH meter and the electrode support will accept a variety of electrodes for performing pH determinations and electrode potential measurements. The **ref. A** and **input A** jacks accommodate pin and BNC type cable plugs respectively; the electrode support holder accommodates a standard electrode pair, a standard combination electrode and a micro-combination electrode.

To mount an indicator, reference, or combination electrode, perform the following steps:

1. Insert the electrode tip into one of the semi-circular slots located along either side of the electrode holder.
2. Lower the electrode until electrode top cap is firmly seated in the slot.

Electrode Support Adjustment

Adjust the electrode support as follows:

1. Maneuver support into approximate desired operating position.

Adjust friction knobs on support until support maintains a set position but can be raised or lowered at the touch of a finger.

Electrode Connections

Connect the electrode cable leads to the pH meter as follows:

NOTE: *At this point, the electrode should be properly conditioned according to manufacturer's instructions. The electrode should be soaked in a KCl solution or a pH 7 or pH4 buffer for a few hours (preferably overnight) prior to use.*

1. Remove the shorting cap from the **input A** BNC jack.
2. The combination electrode is attached by connecting the BNC connector to the jack marked **input A**. If an electrode pair is being used, connect the reference electrode to the jack marked **ref. A**, and connect the indicating electrode (pH, ion selective, or metallic) to the jack marked **input A**.

NOTE: *If an indicator electrode with a pin-jack is to be used, a pin-jack connector adaptor should be connected between the **input A** BNC jack and the pin from the indicator electrode. See Accessories on page 21.*

pH Measurement

Prior to making one or a series of pH measurements, the pH meter must be standardized to compensate for the difference in the zero potential of the electrode. This requirement is accomplished by immersing the electrode into a buffer solution of known pH value and adjusting the **standardize** knob so the meter reads the specified value of the buffer. For further clarification see *Basic pH Theory* on page 16.

In pH meter standardization, as well as in pH measurement, attention must be given to the temperature of both the buffer and the sample solutions since the pH of a solution changes with temperature (buffer pH at a specified temperature is usually indicated on the manufacturer's label). Moreover, temperature affects the voltage output of the electrode. During operation, the latter is compensated by manually adjusting the **temperature** control first to the temperature of each buffer, then to that of each sample.

The Model 10 may be equipped with an atc probe, which replaces the manual temperature control and provides automatic temperature correction for pH measurements.

NOTE: *Proper electrode care is fundamental to obtaining reliable pH measurements. Improper care of electrode may cause the meter reading to drift, respond slowly, or produce erroneous readings. For this reason, the electrode should always be conditioned and used in accordance with manufacturer's instructions.*

One Point pH Standardization

To perform pH measurements using the manual **temperature** control, proceed as follows:

1. Set the **function** selector to **pH** position.
2. Set the **slope** control to 100%.
3. Select a buffer which has a pH value within 1 or 2 units and a temperature within ± 10 °C of the solution to be measured.
4. Immerse the electrode and a thermometer into the buffer solution.
5. Wait until electrode and buffer solution reach thermal equilibrium (about two minutes), then adjust **temperature** control to agree with the indicated temperature of the buffer solution.
6. Determine the exact pH of the buffer solution from a table of the buffer pH versus temperature (usually found on the label). Adjust the **standardize** control until the display indicates the pH of the buffer solution.
7. Remove the electrode and thermometer from the buffer solution.
8. To avoid contamination of one solution with another, rinse the electrode and the thermometer with deionized or distilled water, or a portion of the next sample, before proceeding with pH measurements.
9. Immerse the electrode and thermometer into sample solution.

10. Wait until the electrode, thermometer and sample solutions reach thermal equilibrium. Then adjust **temperature** control to agree with the indicated temperature of sample solution.
11. Read pH of sample from display, and record value.
12. Remove the electrode and thermometer from solution.
13. Rinse the electrode and thermometer with deionized or distilled water, or a portion of the next sample (discard that portion after rinsing electrode), before proceeding with next measurement.
14. Repeat steps 9 through 13 for with additional samples to measure their pH.

For Model 10 Only:

One Point pH Standardization with Automatic Temperature Compensation (using an ATC probe)

When performing pH measurements the operator may use an ATC probe in lieu of manual **temperature** control. The ATC probe is particularly useful when continuously measuring and recording the pH of a solution that changes temperature or when measuring samples that vary widely in temperature.

To perform pH measurements using an ATC probe, proceed as follows:

1. Set the **function** selector to the **pH** position.
2. Set the **slope** control at 100%.
3. Insert the atc probe into the large center hole of the electrode holder until the cap seats.
4. Insert the probe cable plug into the **atc** jack on rear panel of the pH meter.

NOTE: *The manual **temperature** control is disconnected from the measuring circuit when the compensator is connected to the instrument.*

5. Select a buffer that has a pH value within 1 or 2 pH units and a temperature $\pm 10^{\circ}\text{C}$ of the solution to be measured.
6. Immerse the electrode system and ATC probe into a buffer solution.
7. Wait until the electrode system and buffer solution reach thermal equilibrium, then determine the exact pH of buffer solution from a table of buffer pH versus temperature (usually found on the buffer the label). Adjust the **standardize** control until the display indicates the pH of the buffer solution.
8. To avoid contamination of one solution with another, rinse the electrode and ATC probe with deionized or distilled water, or a portion of the next sample (discard that portion), before proceeding with pH measurements.
9. Immerse the electrode and ATC probe into sample solution.
10. Wait until the electrode and sample solutions reach thermal equilibrium.
11. Read pH of sample from display, and record value.

Two-Point pH Standardization

All electrodes have potentials and response "slopes" that change with age, and pH electrodes rarely reproduce the Nernstian theoretical output of 59.16 mV per pH unit at 25°C. Therefore, to measure the pH values of samples that vary over a range wider than about 2 pH units, a two-point standardization method should be employed to compensate for non-ideal electrode efficiency. The **standardize** control is used to set the first point, and the **slope** control sets the second point.

At pH 7, the **slope** control has no effect on the reading. But as readings increasingly differ from pH 7, the slope effect becomes more pronounced. For this reason, a pH 7 buffer always is recommended as the first standard.

To perform a two-point standardization, proceed as follows:

1. Set the **function** selector to the **pH** position.
2. Set the **slope** control to 100%.
3. Obtain two buffer solutions with values that bracket the desired measuring range, (e.g., pH 4.0 and pH 7.0 for samples that fall between pH 4 and 7.)

NOTE: For best results, all solutions should be at the same temperature.

4. Place a beaker, containing the buffer nearest in value to pH 7, in position and immerse the electrode and thermometer or atc probe into the solution.
5. For manual temperature compensation, allow about two minutes for the thermometer to equilibrate, then set the **temperature** control to the corresponding temperature.

NOTE: When using the manual temperature control set the temperature for samples of varying temperature, be sure to set the control to the temperature of the each sample. With the Model 10, when using automatic temperature compensation with an ATC probe, it is not necessary to set the temperature (the manual temperature control is disconnected).

6. Adjust the **standardize** control until display indicates exact buffer value (determine from the temperature of the buffer).
7. Remove the electrode and thermometer from the buffer solution.
8. Rinse the electrode and thermometer with deionized or distilled water or a portion of the next sample (discard that portion).
9. Place a beaker containing the second buffer in position, and immerse the electrode (and thermometer or atc probe if used) into the solution.

NOTE: With buffer and sample solutions maintained at the same temperature, there should be no need to readjust the temperature control.

10. Adjust the **slope** control until the display indicates the exact buffer value (determine from the temperature of the buffer).

NOTE: *If the slope control can not be adjusted for the second buffer to read correctly, electrode response (slope) is showing significant error. The electrode may be bad, and may need to be replaced.*

11. Remove the electrode from the buffer and rinse with distilled water or a portion of the next sample (discard that portion).
12. Measure the pH of samples as previously described, being careful not to change positions of the **standardize** or **slope** controls.

Millivolt Measurement

The meter is a convenient tool for measuring electrode potential and indicating results in millivolts. There is no need to standardize the pH meter with a buffer solution. Readings can be taken as soon as the millivolt zero reference is established.

With the preliminary procedures completed, perform millivolt or redox measurement as follows:

1. Set the **function** selector to the **mV** position.
2. Short the **input A** jack of the meter by placing the BNC shorting cap attached to the meter onto the **input A** BNC connector.
3. Adjust the **standardize** control until display indicates 0 millivolts.
4. Remove the shorting cap from **Input A**.
5. Mount and connect the electrode(s) as directed by *Electrode Installation* under
6. Immerse the electrode(s) into sample solution.
7. Allow sufficient time for the electrode to reach equilibrium with the sample solution (normally about two minutes).
8. Read the millivolt potential of the sample from the display.
9. Remove the electrode from the solution.
10. To avoid contamination, rinse the electrode with deionized or distilled or a portion of the next sample (discard that portion) before proceeding with next measurement.
11. Repeat steps 6 through 10 for remaining samples.

Using mV Measurements

Millivolt measurements have two main analytical uses, for ion concentration measurements and for redox potential (also called oxidation reduction potential, ORP) measurements.

Ion concentrations can be measured using millivolt potentials from ion selective electrodes, along with concentration vs potential graphed calibration lines or best-fit equations. In the direct concentration method, the millivolt potentials in one or more standard solutions are measured, graphed, and a "working curve" established. Millivolt readings in sample solutions can then be read off the graphed calibration line to determine the actual ion concentrations. Known or standard addition methods measure the millivolt potentials of a sample solution before and after adding a known amount of a standard solution. The millivolt values are used in equations to calculate the ion concentration. Ion measurements are typically made with an ion selective electrode (ISE), which senses the concentration of a particular ion, with a reference electrode.

Redox potential, or ORP, millivolt measurements indicate the oxidizing or reducing capability of a solution, and are controlled by the ratio of oxidants to reductants present. ORP values may be used to monitor or control solutions where a set amount of oxidants or reductants is desired.

Another common use of redox measurements are during redox titrations, where a solution is

titrated with either an oxidant or reductant as the analytical reagent, and the redox potential of the solution during the titration is used to determine the titration equivalence point or endpoint. Redox measurements are typically made with a platinum indicator electrode, which senses the oxidation/reduction equilibrium, and a reference electrode.

Basic pH Theory

Summary

Since its' introduction in 1909, the measurement of pH has become increasingly more important in both laboratory and industrial environments. The close control of pH is of primary importance in life processes; control of acidity is essential in sanitary engineering and electroplating and in the textile, pharmaceutical and food industries.

Modern instrumentation and the availability of a wide variety of electrode styles have made the measurement of pH almost as simple and convenient as the measurement of temperature. In general, pH is a measure of the degree of acidity or alkalinity of a substance. It's related to the effective or active acid concentration of a solution by this equation:

$$\text{pH} = -\log \alpha_{\text{H}^+}$$

with α_{H^+} representing the activity of the hydrogen ions in the solution. Neglecting activity effects, the equation above reduces to:

$$\text{pH} = -\log [\text{H}^+]$$

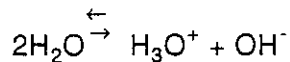
with $[\text{H}^+]$ representing the **concentration** of the hydrogen ions in the solution. pH is sometimes referred to as the **power of the hydrogen ion** in solution. Thus, the pH of the strong acid 0.01 molar HCl is equal to 2, since the hydrogen ion concentration is 10^{-2} molar:

$$\text{pH} = -\log [10^{-2}]$$

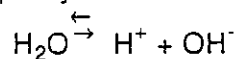
$$\text{pH} = 2$$

The pH scale in water usually ranges from 0 to 14, or from an active acid concentration of $[1 \times 10^0]$ to $[1 \times 10^{-14}]$ (1.0 molar to 0.00000000000001 molar). Although concentrations outside this range can and do exist, they are not generally encountered in practice.

The pH scale is based on the **dissociation constant** of water. In pure water, a very small number of molecules react with one another to form hydronium ions (H_3O^+) - which account for acidic properties and hydroxide ions (OH^-) - which account for the basic properties of an aqueous solution.



or for simplicity:



At 25°C, pure water dissociates until the acid $[\text{H}^+]$ and base $[\text{OH}^-]$ concentrations are equal, at 1×10^{-7} molar. The product of both concentrations is the dissociation constant K_w :

$$K_w = [\text{H}^+][\text{OH}^-]$$

$$K_w = [1 \times 10^{-7}][1 \times 10^{-7}]$$

$$K_w = [1 \times 10^{-14}]$$

Because the hydrogen ion concentration $[H^+]$ equals 1×10^{-7} molar, the **pH of pure water at 25°C is 7**. This is referred to as the **neutrality point**.

In aqueous solutions at the 25°C, the product of $[H^+]$ and $[OH^-]$ must always remain constant at 1×10^{-14} . Therefore, an increase in either the acid or base concentration will always result in a decrease in the other term. Hence, a solution of the strong base 0.01 M NaOH will have a hydrogen ion concentration of:

$$[H^+] = \frac{K_w}{[OH^-]} = \frac{10^{-14}}{10^{-2}} = 10^{-12}$$

Thus:

$$\text{pH} = -\log[10^{-12}]$$

$$\text{pH} = 12$$

The pH scale chart shows the relationship of pH value to the active concentration of hydronium ions in solutions.

pH Scale

Active Acid Concentration [H ⁺]		pH	Active Base Concentration [OH ⁻]	
10 ⁰	1.0		0	0.0000000000000001
10 ⁻¹	0.1	1	0.000000000000001	10 ⁻¹³
10 ⁻²	0.01	2	0.00000000000001	10 ⁻¹²
10 ⁻³	0.001	3	0.000000000001	10 ⁻¹¹
10 ⁻⁴	0.0001	4	0.0000000001	10 ⁻¹⁰
10 ⁻⁵	0.00001	5	0.000000001	10 ⁻⁹
10 ⁻⁶	0.000001	6	0.00000001	10 ⁻⁸
Neutrality				
10 ⁻⁷	0.0000001	7	0.0000001	10 ⁻⁷
10 ⁻⁸	0.00000001	8	0.000001	10 ⁻⁶
10 ⁻⁹	0.000000001	9	0.00001	10 ⁻⁵
10 ⁻¹⁰	0.0000000001	10	0.0001	10 ⁻⁴
10 ⁻¹¹	0.00000000001	11	0.001	10 ⁻³
10 ⁻¹²	0.000000000001	12	0.01	10 ⁻²
10 ⁻¹³	0.0000000000001	13	0.1	10 ⁻¹
10 ⁻¹⁴	0.00000000000001	14	1.0	10 ⁰

Note: The above explanation of hydronium ion concentration is a simplified one. Active hydronium ion concentration is in fact influenced by a number of factors, including temperature, ion strength, dielectric constant, ion charge and size, and the density of the solvent. For a more complete treatment, refer to a text on the subject, such as "Determination of pH: Theory and Practice", Roger G. Bates, John Wiley and Sons Inc., New York.

Electrode measurement of pH is based on the fact that, when certain electrodes are immersed in a solution, a voltage is produced which is related in a very precise way to the pH of the solution. This voltage can be predicted by the Nernst equation. In simplified form, the equation is:

$$E_{\text{meas}} = E^{\circ} - \frac{2.3 RT}{nF} \cdot \text{pH}$$

where E_{meas} is the measured voltage; E° is the total of all constant voltages in the measuring system; R is the Gas Law constant; T is the temperature in $^{\circ}\text{K}$; n is the number of electrons; and F is Faraday's constant.

The measuring system is composed of:

1. **Two electrodes** - a *glass indicating electrode*, which develops a potential dependent on the pH in a solution; and a *reference electrode*, which provides a constant potential and completes the electrical circuit. (Alternatively, a combination electrode, comprised of an indicating electrode and reference electrode joined, may be used.)
2. **A pH meter or electrometer** - a device capable of measuring small potential differences in a circuit of high resistance.
3. **One or more standard solutions** of known pH value for proper standardization of the system.

Electrodes

The pH-sensing electrode - usually called simply a "glass electrode" - is contained in a nonconducting glass tube, called the body. This is sealed to a bulb of special conductive glass - the pH-sensing **membrane**.

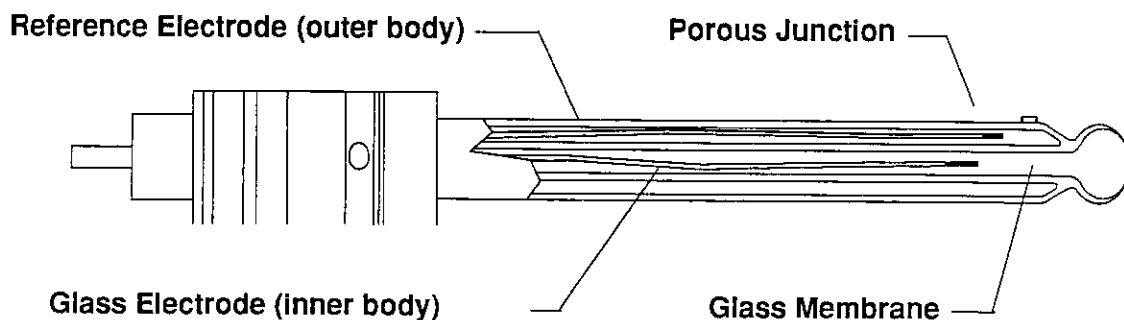


Figure 3: The Combination Electrode

The body is filled with a buffered electrolyte whose pH value and ionic concentration are fixed. An **internal reference element**, typically Ag/AgCl , is immersed in this filling solution.

This design assures that constant potentials are developed on the **inner surface** of the glass membrane, and on the internal reference element. When the electrode is immersed in a solution of pH 7, the sum of these of fixed voltages approximately balances the voltage developed on the **outer surface** of the glass membrane and the separate **reference electrode**. Thus, the total

potential output of the system is near 0 mV. In solutions of pH more or less than pH 7, the potential on the outer membrane surface changes in proportion to the sample pH. The voltage change is sensed by the meter and displayed as a pH value.

One major requirement of the reference electrode is to complete the electrical measuring circuit. A simple wire, immersed in the sample solution, could satisfy this purpose. But this simplified arrangement would be susceptible to voltage changes, dependent on the time in the solution and the sample composition. Such voltage changes would be unacceptable, of course, because the second, and most important, requirement of a reference electrode is to provide a stable reference potential.

Hence, a reference element - usually calomel or silver/silver chloride - is immersed in an electrolyte filling solution of fixed ionic concentration, contained in the probe body. This produces the required constant voltage, no matter what the sample composition. The electrical circuit is completed by allowing a small flow of the electrolyte to pass through a porous junction in the probe tip; or by ionic diffusion in an electrode with gelled electrolyte.

As its name implies, the combination electrode contains both the sensing and reference electrodes, co-axially joined in a single probe body. The glass pH-sensing electrode is enclosed in a tube, with its membrane exposed at the probe tip. The annular space surrounding the inner tube contains the reference element, electrolyte and junction.

Main advantages of the combination electrode are its convenience in handling - especially in field use - and its ability to allow measurements in small sample vessels where an electrode pair would not fit.

Appendix

Accessories

The following is a list of accessories that may be useful in a variety of applications. Additionally, contact Denver Instrument Company for a full line of buffers, electrodes, and other pH related materials.

<u>Accessory Items</u>	<u>Cat. No.</u>
Standard Glass Body Combination Electrode	13-620-285
pH Electrode (Gel-filled)	13-620-108
Automatic Temperature Compensation Probe	13-620-16
BNC to Pin-Jack Adaptor	13-620-490
Thermometer (0 to 100°C)	13-640-280
Free Standing Electrode Support Assembly	13-637-675
Electrode Support Assembly (attaches to meter)	13-637-672
Fisher Buffer-Pac (one 500ml bottle each pH 4, 7, 10,)	SB 105
Buffer 4.00, 500ml, color-coded red	SB 101-500
Buffer 7.00, 500ml, color-coded yellow	SB 107-500
Buffer 10.00, 500ml, color-coded blue	SB 115-500

Maintenance

Maintenance is limited to periodic cleaning of the case with a damp cloth. A mild detergent may be used for a more thorough clean up. **NEVER** use a chemical solvent on the case.

WARNING! *Secured access panels, covers, and etc. should never be removed from this equipment by anyone other than experienced service personnel.*

Technical Assistance and Return Shipping Instructions

- Please return the prepaid, pre-addressed Purchase Registration Card to the manufacturer promptly upon your purchase of the product. The return of the card is not a condition precedent to warranty coverage.
- Call the Electrochemistry Hotline at 1-800-338-8355 to determine a solution to the problem. If further technical assistance is needed, contact Customer Service at: 1-800-321-1135.
- A **Return Authorization Number** from Customer Service is required for all returned units.
- Write a detailed description of the unit malfunction on the packing slip.
- Unplug and remove the power supply.
- Place the pH meter and power supply in the original shipping carton. Secure the unit with the original packing material. If the original packing is not available, call the Customer Service number. **The factory packing must be used!**
- Enclose the packing slip.
- Close the carton and secure with appropriate packing tape.
- Write the return authorization number on the outside of the carton.

Ship to: Denver Instrument Company
6542 Fig Street
Arvada, CO 80004

Upon receipt and inspection of the defective unit, we will promptly repair or replace your unit. Units which have not been maintained in accordance with the operating instructions, or have been misused or abused, will be repaired and returned with service charges.

TWO YEAR LIMITED WARRANTY

The manufacturer warrants to the original retail purchaser, for a period of two years from the date of invoice, that the accumet® product is free from defects in material and workmanship. In the event of failure within the warranty period, the manufacturer will repair or replace at its option, a defective product when used under normal laboratory conditions and in accordance with the operating limitations and maintenance procedures as outlined in the instruction manual and when not having been subjected to accident, alteration, misuse, or abuse. The defective product, accompanied by a Return Authorization Number, must be delivered to the manufacturer (or its authorized dealer), freight prepaid and securely packaged, during the warranty period by the original purchaser of the unit. THE MANUFACTURER SHALL NOT BE LIABLE TO THE PURCHASER OR ANY THIRD PARTY FOR ANY LOSS, INCONVENIENCE, OR DAMAGE, WHETHER DIRECT, INCIDENTAL, CONSEQUENTIAL, OR OTHERWISE, RESULTING FROM ANY BREACH OF THIS WARRANTY OR ANY ACT OF OMISSION OF THE MANUFACTURER, ITS DIRECTORS, OFFICERS, EMPLOYEES, OR AGENTS.

GENERAL DISCLAIMER: THIS WARRANTY IS MADE IN LIEU OF ALL OTHER WARRANTIES, EXPRESS, IMPLIED, OR STATUTORY, INCLUDING THE WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, AND DESIGN AND ALL WARRANTIES ARISING FROM THE COURSE OF DEALING OR USAGE OF TRADE.

Some states do not all allow limitations on how long an implied warranty lasts or the exclusion or limitation of incidental or consequential damages, so the limitations or exclusion above may not apply to you. This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

For your reference and protection, record:

Model Number _____

Serial Number _____

Purchase Date _____

