

pH Meter

Introduction: تركي الصالح الخليلي

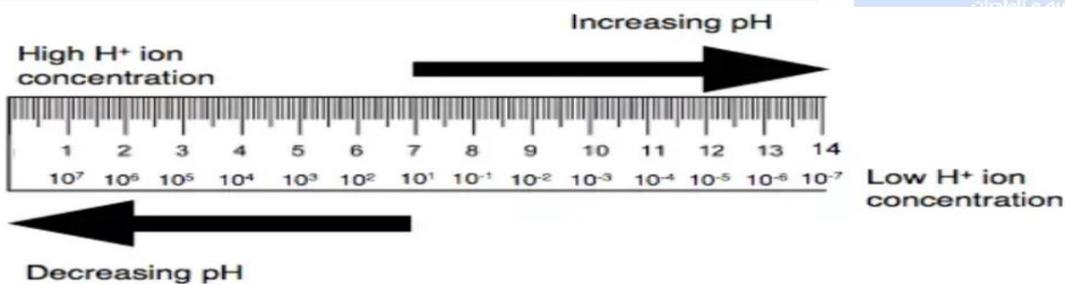


pH indicates the concentration of Hydrogen ions in a solution. pH signify the power of hydrogen. To comprehend pH theory, it is necessary to comprehend water dissociation.

The pH scale was formed from water's spontaneous dissociation. Water dissociates spontaneously into its H^+ and OH^- components. In pure water, the concentration of H^+ ion is 1×10^{-7} . This H^+ ion concentration is neutral, meaning it is neither acidic nor alkaline.

When the concentration of H^+ ions is greater than $1 \times 10^{-7}M$, the solution is acidic; when the concentration is less than $1 \times 10^{-7}M$, the solution is alkaline. Low pH indicates a high concentration of H^+ ions; high pH indicates a low quantity of H^+ ions. Therefore, the pH scale is inversely proportional to the concentration of H^+ in any particular solution and proportional to the concentration of OH^- ions.

$$pH = -\text{Log}^{10} [H^+]$$



A pH meter is a valuable tool used in various. It provides precise measurements by assessing the movement of hydrogen ions within the suspension, which is then expressed as pH. The term "pH" is derived from the "p," which stands for the negative logarithm, and "H," the chemical symbol for Hydrogen.

The fundamental principle behind a pH meter lies in potentiometric measurement. It involves detecting the variation in electrical potential between two electrodes: a pH electrode and a reference electrode. The pH electrode is specifically designed to respond to changes in hydrogen-ion concentration, while the reference electrode provides a stable electrical potential. By comparing these two potentials, the pH meter can determine the acidity or alkalinity of the solution.

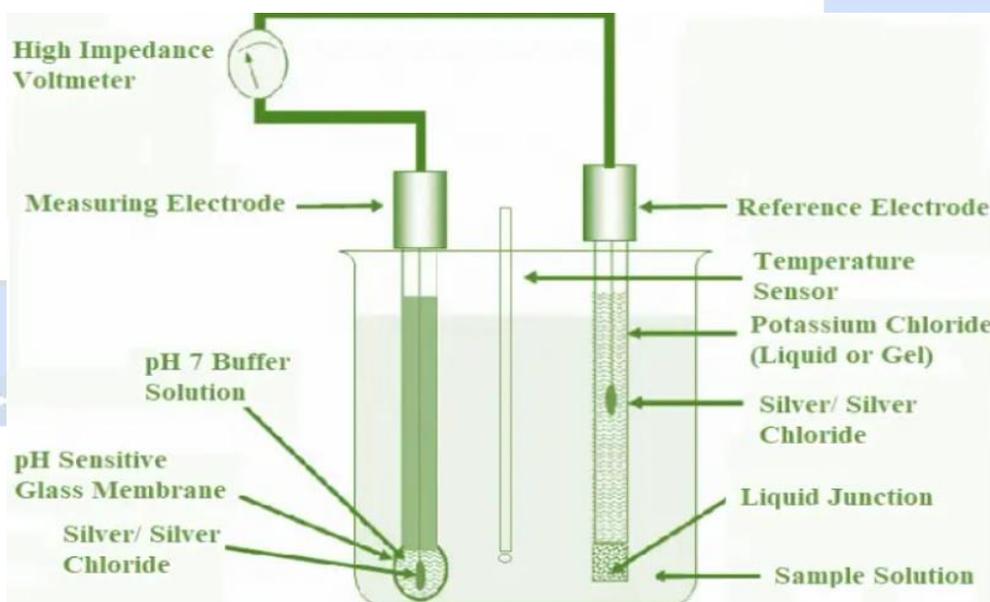
pH Meter Working Principle:

The principle of pH meter is based on the exchange of ions between the sample solution and the inner solution of the glass electrode. This exchange occurs through the glass membrane, allowing the pH meter to measure the acidity or alkalinity of the solution.

A pH meter consists of a pH probe that conducts electrical signals to the pH meter itself, which then displays the pH value of the solution. The pH probe comprises two electrodes: a sensor electrode and a reference electrode. The sensor electrode is filled with a pH 7 buffer, while the reference electrode is filled with saturated potassium chloride solution. The sensor electrode bulb is coated with metal salts and silica, forming a porous glass membrane.

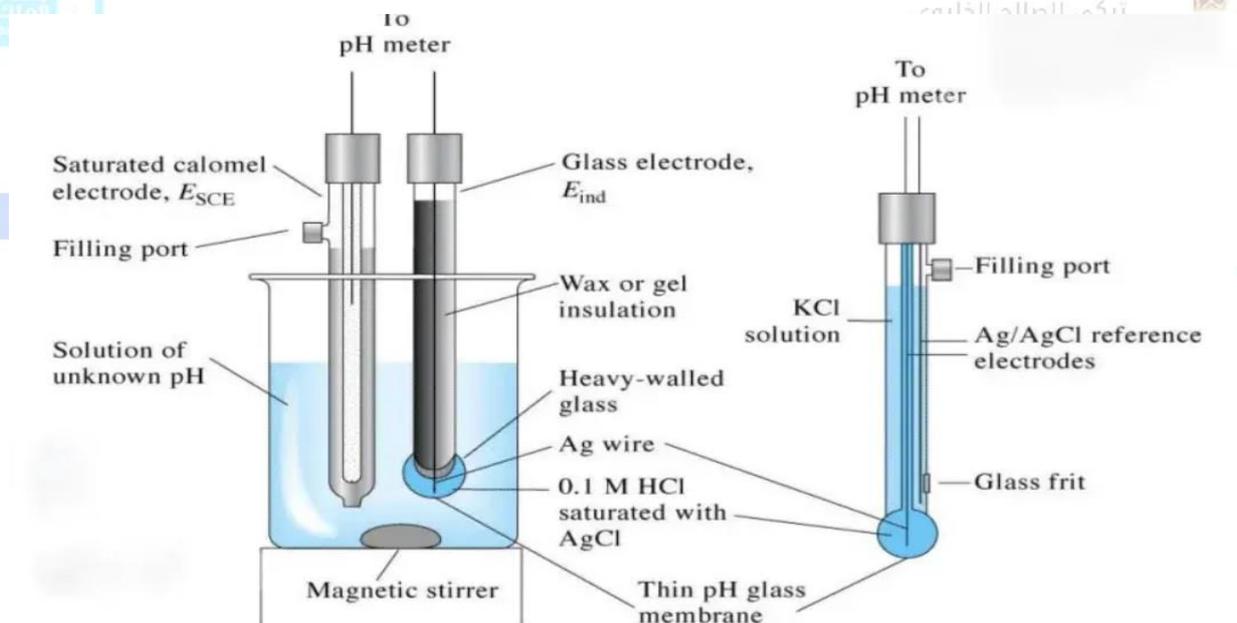
When the pH probe is immersed in a sample solution to measure the pH, hydrogen ions accumulate around the bulb and replace the metal ions within the electrode. At the same time, some metal ions from the glass electrode transfer to the sample solution. The reference electrode, which has low sensitivity or complete insensitivity to pH changes, provides a constant voltage. This voltage generates an electrical current that is captured by a silver wire, creating a potential difference related to the activity of hydrogen ions. The pH meter compares this voltage to the reference electrode and converts it into a pH value.

An increase in acidity of the solution leads to a higher concentration of hydrogen ions, which in turn increases the voltage measured by the pH meter. Consequently, the pH reading on the pH meter decreases. Conversely, an increase in alkalinity or the concentration of hydroxyl ions reduces the voltage, resulting in an elevated pH reading on the pH meter.



Parts of a pH meter:

A pH meter is a device used to measure the acidity or basicity (pH) of a solution. It typically consists of the following parts:

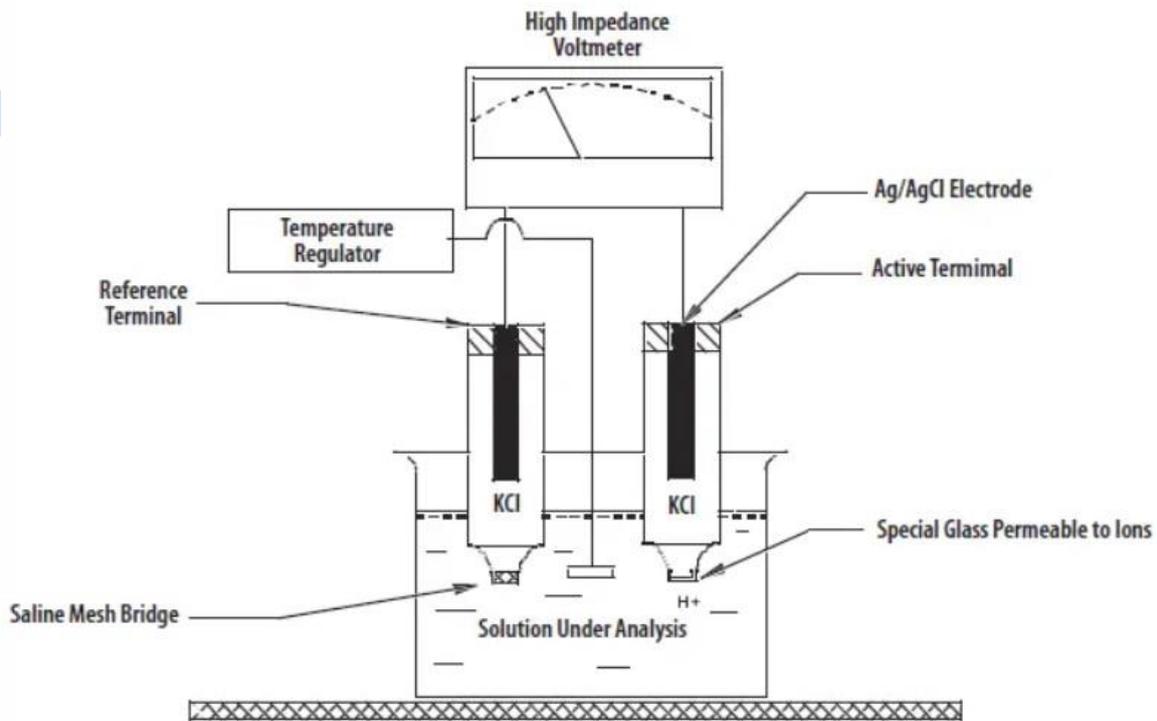


A pH meter consists of several essential parts that work together to accurately measure the pH of a solution:

1. **Electrode:** The electrode is responsible for directly measuring the pH of the solution. It consists of a glass bulb filled with a pH-sensitive solution and a metal wire that extends into the solution.
2. **Reference electrode:** The reference electrode provides a stable reference point for pH measurement. It typically consists of a silver wire coated in silver chloride and is immersed in a solution of potassium chloride.
3. **Meter:** The meter is the display unit of the pH meter.
4. **Temperature probe:** Some pH meters are equipped with a temperature probe.
5. **Power source:** Most pH meters are battery or electrical-powered.
6. **Case:** The case provides protection for the delicate components of the pH meter.
7. **Sample chamber:** It is a small container that holds the solution.
8. **Calibration solution:** This allows the meter to be adjusted for accurate measurements.
9. **Amplifier:** The amplifier is a crucial component that amplifies the voltage signals generated by the electrodes.
10. **High input impedance meter:** This component is responsible for processing the tiny electrode voltages and displaying the pH measurements in pH units.

- Combined electrode:** The combined electrode contains both the reference electrode and the pH glass electrode. It is where the actual pH measurement takes place.
- Thermometer probe:** Some pH meters feature a built-in thermometer probe

By combining these components, a pH meter enables accurate and reliable measurement of the acidity or alkalinity of a solution.



Combined Electrodes:

The combined electrode is an essential component of a pH meter, and it consists of several parts that enable accurate pH measurement:

- Glass bulb:** A sensor measures the concentration of hydrogen ions (H^+) in the solution. It is made of specialized glass and contains a membrane that allows ion exchange between the sample solution and the internal solution.
- Internal electrode:** A silver chloride electrode. It serves as the internal reference for the pH measurement.
- Internal solution:** It is immersed in a buffer solution, usually potassium chloride (KCl), with a pH of 7.
- Reference electrode:** It is also composed of a silver chloride electrode. It provides a known reference potential against which the pH measurement is compared.
- Internal solution:** The reference electrode is immersed in a buffer solution of potassium chloride (KCl) with a pH of 7..

How to calibrate pH meter?

Calibration of the pH metre is a crucial duty that must be performed daily before to doing any tests with the pH metre.

Utilize the pH metre and electrode system in accordance with the manufacturer's instructions or the pertinent SOPs. All measurements should be conducted between 20 and 25 degrees Celsius. The device is calibrated with the potassium hydrogen phthalate buffer solution (primary standard) (buffer pH 4.0) and another buffer solution with a different pH, preferably buffer pH 10. The pH measurement of a third buffer with a pH of 7.0 must not vary by more than 0.05 units.

- 1 **Select Calibration Buffer:** Choose the appropriate pH buffer solution for calibration. pH meters are commonly calibrated using pH 4, pH 7, and pH 10 buffer solutions.
- 2 **Immerse the Electrode:** Immerse the pH electrode in the pH 10 buffer solution. Ensure that the electrode is fully submerged in the solution And repeat for 7 & 4.
- 3 **Temperature Adjustment:** Determine the temperature of the buffer solution using a thermometer, if necessary.
- 4 **pH Mode Selection:** Set the Function Switch on the pH meter to the pH Mode.
- 5 **Calibration Knob Adjustment:** Adjust the "Calibrate" knob on the pH meter until the display reads 10, matching the pH value of the calibration buffer solution.
- 6 **Function Switch Reset:** Turn the Function Switch back to the Standby position after calibration. This prepares the pH meter for the next step in the calibration procedure.
- 7 **Rinse the Electrode:** Remove the pH electrode from the pH 10 buffer solution and rinse it thoroughly with distilled water.
- 8 **Multiple Buffer Solutions:** Place the pH electrode in the first of the remaining buffer solutions. These solutions typically include pH 7 and pH 4.
- 9 **Slope Adjustment:** Adjust the "Slope%" control to match the pH values of Buffers.
- 10 **Rinse the Electrode:** After calibration with the pH 7 buffer solution, remove the electrode and rinse it thoroughly with distilled water to remove any residual solution.
- 11 **Repeat Calibration:** If necessary, repeat steps 7-10 for the remaining buffer solutions.
- 12 **Standby Mode:** Always keep the Function Switch in the Standby position when not in use after pH measurement or calibration.

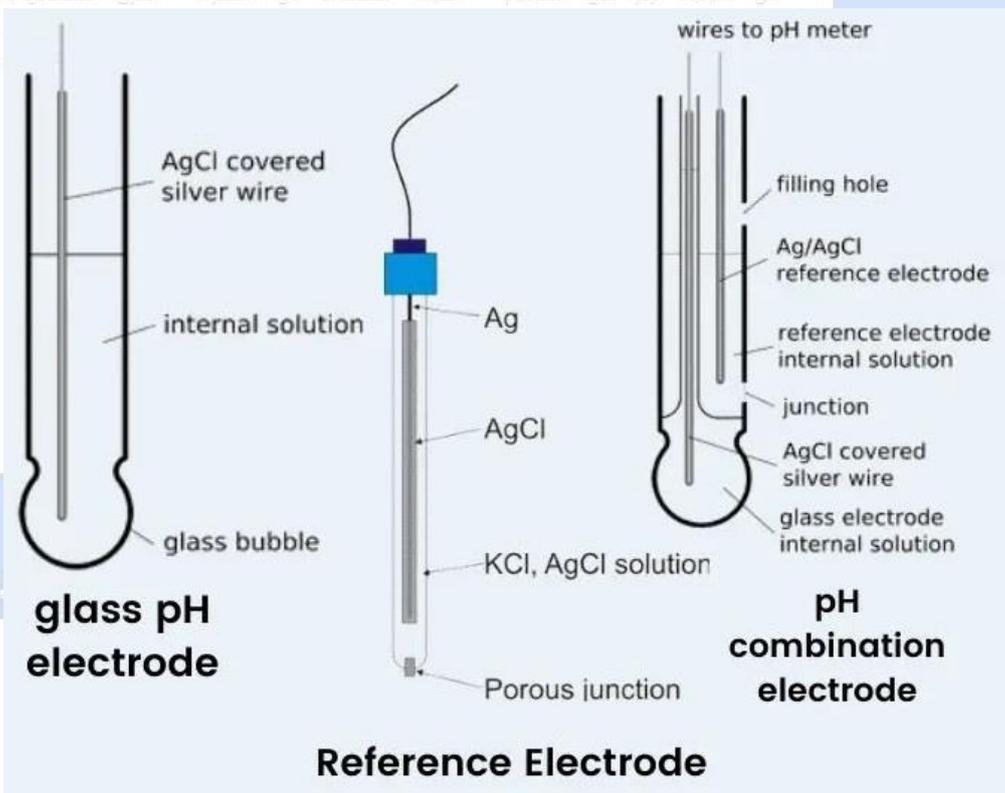
What is pH Electrode?

A pH electrode is a device used to measure the acidity or alkalinity of a solution, which is expressed as its pH value. It consists of two main components: a glass electrode and a reference electrode.

The glass electrode is the sensing element of the pH electrode. It is typically a thin, bulbous-shaped glass membrane that is selectively permeable to hydrogen ions (H^+). The glass membrane interacts with the H^+ ions in the solution being tested, causing an exchange of ions and generating an electrical potential. The potential is directly related to the pH of the solution, with acidic solutions generating a higher potential and alkaline solutions generating a lower potential.

The reference electrode provides a stable reference point for the pH measurement. It is typically a silver/silver chloride ($Ag/AgCl$) electrode immersed in a potassium chloride (KCl) electrolyte solution. The reference electrode maintains a constant electrical potential, serving as a reference against which the potential of the glass electrode is measured. This allows for accurate and consistent pH measurements.

To measure pH, the glass electrode and the reference electrode are connected to a pH meter. The pH meter measures the potential difference between the two electrodes and converts it into a pH value. The pH meter may also incorporate temperature compensation to account for the effect of temperature on pH measurements.



Application of pH Meter:

pH meters have a wide range of applications across various industries and sectors. Here are some common applications of pH meters:

- Agriculture:** pH meters are used in agriculture to assess soil pH levels, which helps farmers to make informed decisions about soil amendments and fertilizer application.
- Water Treatment:** pH meters are used to monitor and control the pH levels of water to ensure it meets regulatory standards and is safe for consumption.
- Industrial Processes:** pH meters are utilized in various industrial processes, including chemical industries. They are used to measure and control the pH of wastewater generated by industries such as steel, paper, pharmaceuticals, biotechnology, and petrochemicals.
- Quality Control in Manufacturing:** pH meters are employed in the quality control of chemical compounds and food products. For example, in the food industry, pH meters are used to monitor acidity levels in dairy products, beverages, sauces, and other food items.
- Medical and Biological Applications:** pH meters are used in medical and biological research to measure the pH of biological fluids such as blood, urine, gastric acid, and cell culture media. Monitoring pH levels provides valuable insights into the physiological and metabolic conditions of organisms and aids in disease diagnosis and treatment.
- Detergent Manufacturing:** They are used to monitor and control the pH of detergent formulations to ensure optimal cleaning performance and stability of the products.

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