I. pH Meter

1. definition

A pH meter is an instrument used to measure the activity of hydrogen ions in solutions. In other words, it measures the acidity or alkalinity of a solution. It is sometimes called a potentiometric pH meter because it measures the difference in electric potential between a pH electrode and a reference electrode . A detailed pH meter diagram is referred here to give a better understanding for our readers..

A pH meter is a statistical tool that monitors the hydrogen-ion activity in water-based solutions, determining its acidity or alkalinity represented as pH.

Word pH means Power /Potential (p) of Hydrogen (H); and serves as the most convenient way to measure the relative alkalinity or acidity at a given temperature. The pH rate is directly linked to the potential of both Hydrogen ions (H+) and Hydroxyl ions (OH-) concentrations.

pH is measured on a scale of 1 to 14 to specify the acidity or basicity of an aqueous solution. The pH of a powerful acid can be less than 0 or greater than 14 for a very powerful base.

- A reading of pH 7 describes the solution as neutral because the activities of both H+ and OH- ions are balanced/equal.
- When the value of pH is less than 7, it means that the activity of H+ ions is greater than that of OH- ions.
- On the contrary, the value of pH increases (higher than 7) when the OH- ions activity in a solution increase at a given temperature.

In search of a better quicker method for testing the pH of solutions, the worlds first modernized electric method was invented by Arnold Orville Beckman – a CALTECH college professor, in 1934, thus paving its way to today's potentiometric pH meters used commercially.

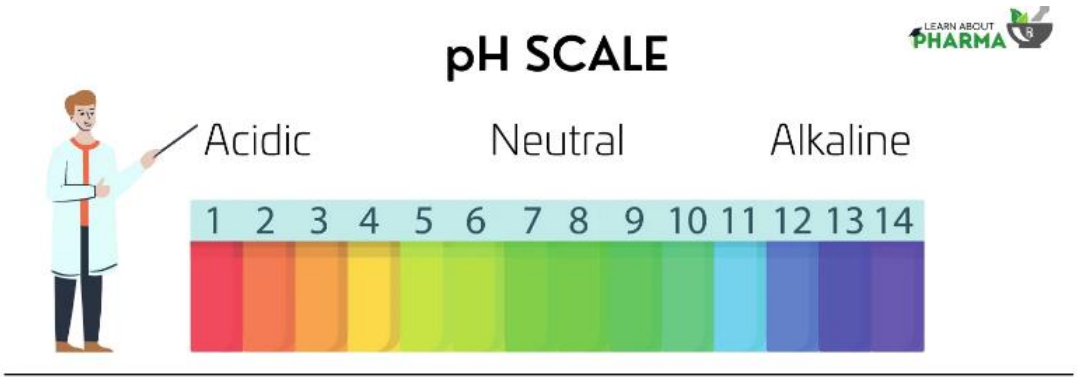


Fig 1: pH scale . https://learnaboutpharma.com/

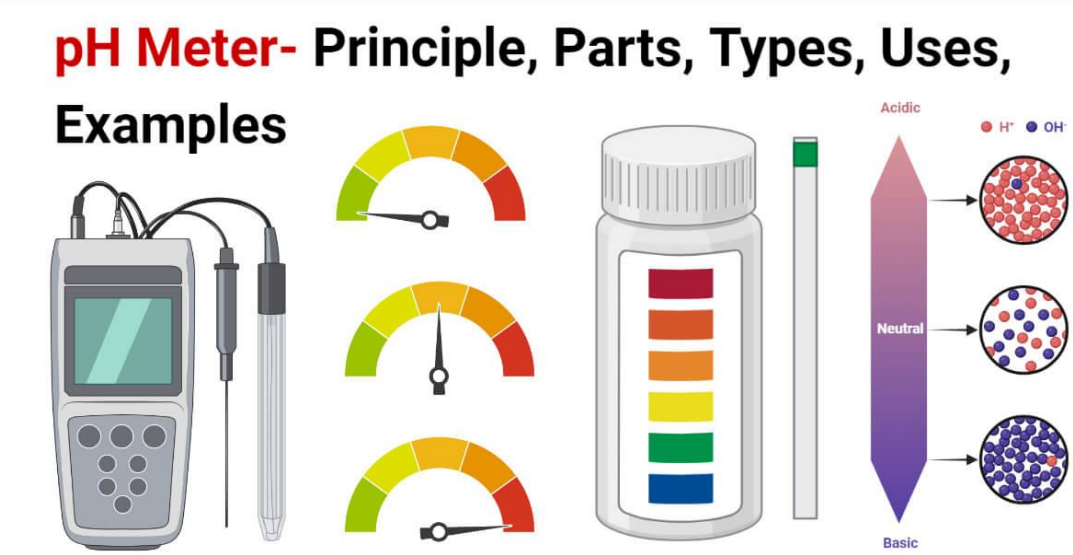


Fig 2: pH Meter. https://microbenotes.com/

2. **Principle of pH Meter**

The working principle of the pH meter relies on the ions exchange from the sample solution to the inner solution (pH 7 buffer) of the glass electrode via the glass membrane. A pH meter has a pH probe to conduct the electrical signals to the pH meter, which then displays the pH value of the solution. The pH probe contains two electrodes, namely a sensor electrode and a reference electrode. One is filled with a pH 7 buffer, and the other with saturated potassium chloride solution. The sensor electrode bulb comprises a porous glass membrane coated with metal salts and silica.

When the probe is submerged in a sample solution to measure the pH, hydrogen ions build up around the bulb and take the place of the metal ions. Similarly, some metal ions transfer from the glass (sensor) electrode to the sample solution. Because of low sensitivity to pH changes or complete insensitivity to pH changes, the reference

electrode potential offers a constant voltage. This generates some electricity captured by the silver wire by generating potential difference (hydrogen-ion activity). The pH meter converts the voltage of this electric flow into pH value by comparing the generated voltage to the reference electrode.

Increasing the solution's acidity results in a higher concentration of hydrogen ions, which raises the voltage. The pH measurement on the pH meter decreases due to the increased voltage. Similar to how an increase in alkalinity reduces hydrogen ions, an increase in the concentration of hydroxyl ions also reduces the voltage and raises the pH reading on a pH meter.

3. **Parts of pH meter**

pH meter consists of three basic elements:

1) **A high input impedance meter**

This is the key component that holds the microprocessor that processes extremely small electrode voltages and displays measurements in pH units on display. The microchip reads the pH of the solution, calculates the measurement temperature, and translates the amplifier voltage value.

2. **The combined electrode**

It consists of two electrodes, where the actual measurement takes place. It is the most expensive, sensitive, and consumable component of the meter that needs to be handled carefully. A reference electrode and a measuring electrode or sensor electrode, both submerged in the same solution, make up the combination electrode. The reference electrode must have a defined stable voltage independent of the measured solution to produce a defined pH value.

Reference electrode: A reference electrode is made up of a reference material (such as mercury, mercury chloride, and saturated solution of potassium chloride) submerged in a specific electrolyte which needs to be interacting with the measured solution most frequently through a porous ceramic junction, have a low electrical resistance due to a high ion concentration and adequate stability across a broad temperature range. It has a known and constant potential.

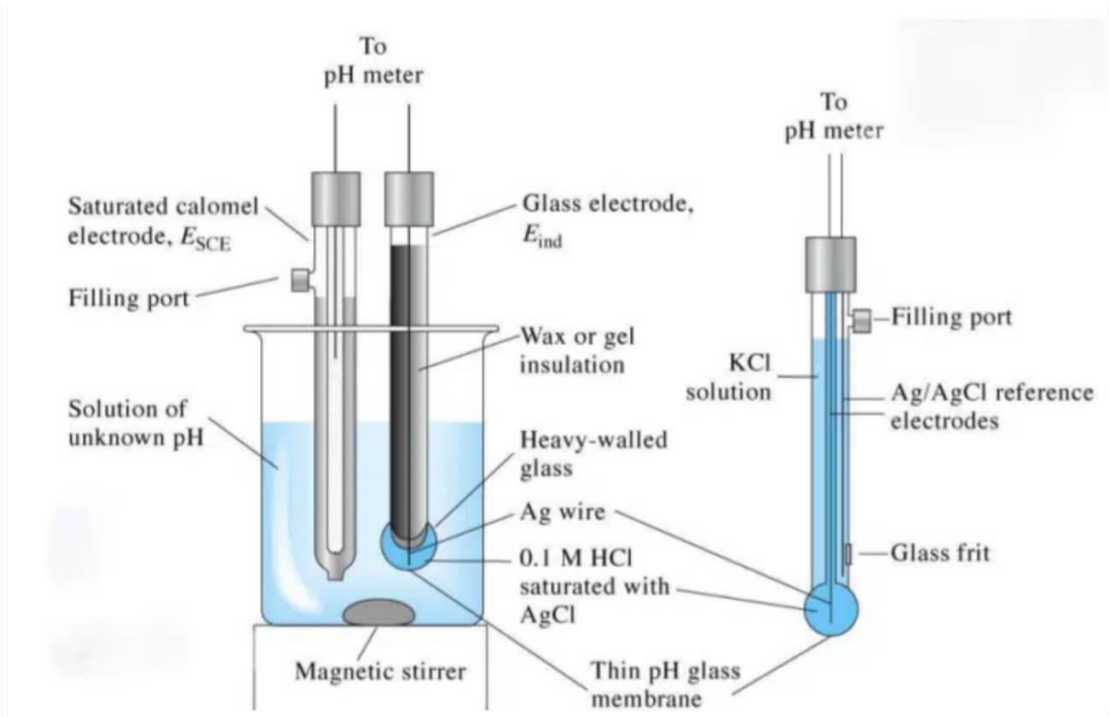
pH glass electrode: It is a glass bulb sensitive to hydrogen ions, and when the relative concentration of hydrogen ions within and outside the bulb changes, so does the millivolt output. It is also known as a sensor electrode or indicator electrode.

3. **Amplifier**

An amplifier, also known as a voltage amplifier, plays a vital role in measuring pH value. The amplifier will increase the accuracy of the pH reading in the same way that a thermometer increases calculations concerning temperature. To precisely measure the amount of acidity, basicity, and neutrality in a solution, this component will ensure that the voltage count is in the pH range of 0–14.

4. **Thermometer probe**

Some pH meters can measure the temperature of the solution being sampled and incorporate that information into the meter reading (the temperature of the solution directly influences pH). This feature is termed “Automatic Temperature Compensation (ATC)”.



Parts of a pH meter

Fig 2: parts Parts of pH meter. Image Source: Pharmaguddu.com. (https://microbenotes.com/)

4. **pH Meter Operating Procedure**

a. Let all the samples get to the same temperature since pH readings rely on temperature. It is advised to compensate for temperature if the samples are not at 25 °C. Determine the temperatures of the samples using a thermometer and manually enter them into the meter, or use an ATC probe to communicate the temperatures automatically.

b. Uncover the sample beakers and prepare the samples.

c. Rinse the pH electrode in the sample beaker after rinsing it with deionized water beforehand. To prevent sample contamination, rinse the electrode with deionized water over a waste beaker. The identical beaker used for sample measurement should never be used to rinse the electrode.

d. The electrode should be inserted into the first sample measurement beaker with the electrode tip and junction completely submerged in the sample. The sample should then be stirred moderately and uniformly.

e. Set the meter to begin taking a reading.

f. Record the pH and temperature of the sample after waiting at least 1 to 2 minutes for a stable reading in the sample.

g. If more samples are needed, repeat steps 3 through 6 again. For the most accurate sample measurements, submerge the electrode in each sample to the same depth. After measuring the samples, clean the electrode with deionized water and put it in a pH electrode storage solution.

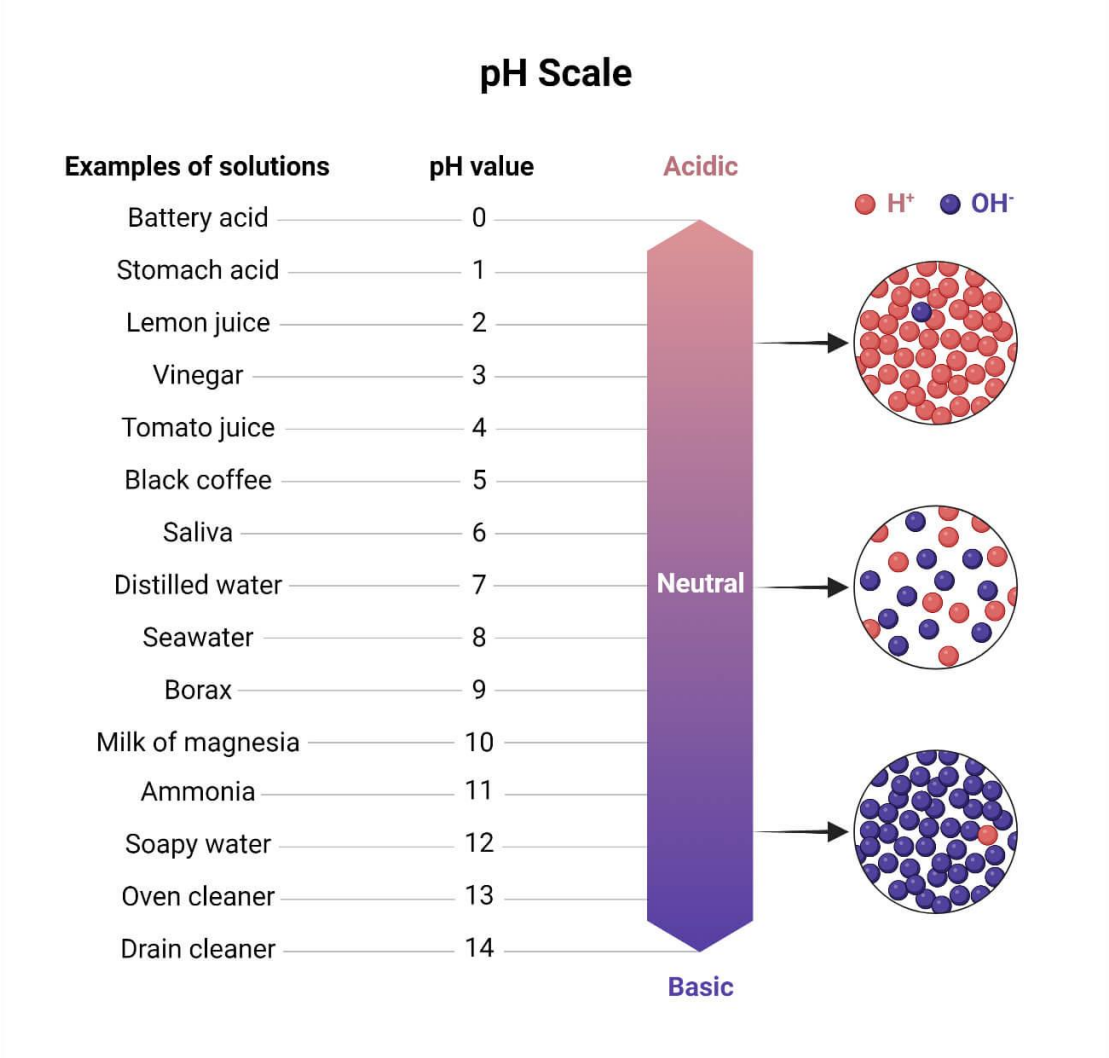


Fig 3: pH Scale with Solution Examples. https://microbenotes.com/

5. Types of pH meters

1) **Based on Portability**

a. **Pen testers:** Pen testers are portable, inexpensive pH meters the size of a pocketbook. The compact form makes them incredibly simple to transport and use while on the road. They are designed with a pH meter, display, and electrode. Pen testers have many uses in the building, hydroponics, food production, and pool or spa care industries.

b. **Handheld meters:** Handheld meters often have a more robust build and a slightly larger shape than pen testers. With this design, the electrode is constructed independently of the meter. Depending on your demands for pH measurement, handheld meters typically feature electrodes you may switch out. For medium-to-

firm items, for instance, spear-tipped electrodes are utilized. Hand-held meters are designed for usage in the field. Environmental officers use them in field research, aquaculture, agriculture, and water treatment.

c. **Benchtop pH meters:** The largest of the three pH meter categories are benchtop meters. They can be put on a wall or a desk. They are often the most accurate pH meters available, which makes them ideal for usage in laboratories and professional settings. Benchtop pH meters are frequently used in laboratories for environmental monitoring, water testing facilities, and food processing facilities.

2) **Based on Usage**

a. **Laboratory pH meter:** It has a large measuring range, is highly accurate, and is versatile.

b. **Industrial pH meter (online):** Its distinctive qualities, which combine analog output, digital intelligence, and upper and lower boundary alarm and control functions, include exceptional stability, steady work, a high level of measurement efficiency, environmental flexibility, and anti-interference capabilities.

c. **Based on advanced level**

3) **Economic pH meter**

a. **Intelligent pH meter**: It has many applications, including water conditioning, aquariums, fish hatcheries, food processing, photography, laboratory, paper industry, etc.

b. **Precision pH meter**: It is further categorized as pointer pH meters and digital pH meters.

4) **Based on reading**

a. **Analog pH meter**

An analog pH meter is the original type of model. A pointer will show the pH level on analog pH meters. The needle will move toward a number representing the pH level after the measuring electrode has been put into the sample. When using an analog pH meter, one must be careful to obtain accurate findings. The little pointer is the reason for this.

b. **Digital pH meter**

The development of analog pH meters led to the creation of the digital pH meter. The number printed on a digital pH meter's measuring device is a clue as to what pH level is being measured. This makes it simpler to obtain accurate results concerning samples. However, the basic operations of analog and digital pH meters are still the same.

6. **Maintenance of PH mètre**

- pH electrodes are sensitive and fragile, so one should not use them as a glass rod to stir the solution while measuring pH.
- pH meters should be calibrated daily before use with the help of standard buffer solutions.
- pH readings are temperature sensitive, so pH meters shouldn't be exposed to sunlight.
- All the test tubes and glass apparatus used in measurement should be cleaned with distilled water before use.
- For each new sample, either uses a brand-new fine dropper or glass rod or thoroughly wash the dropper or rod in water between uses.
- All the solutions used in measurement should be freshly prepared.