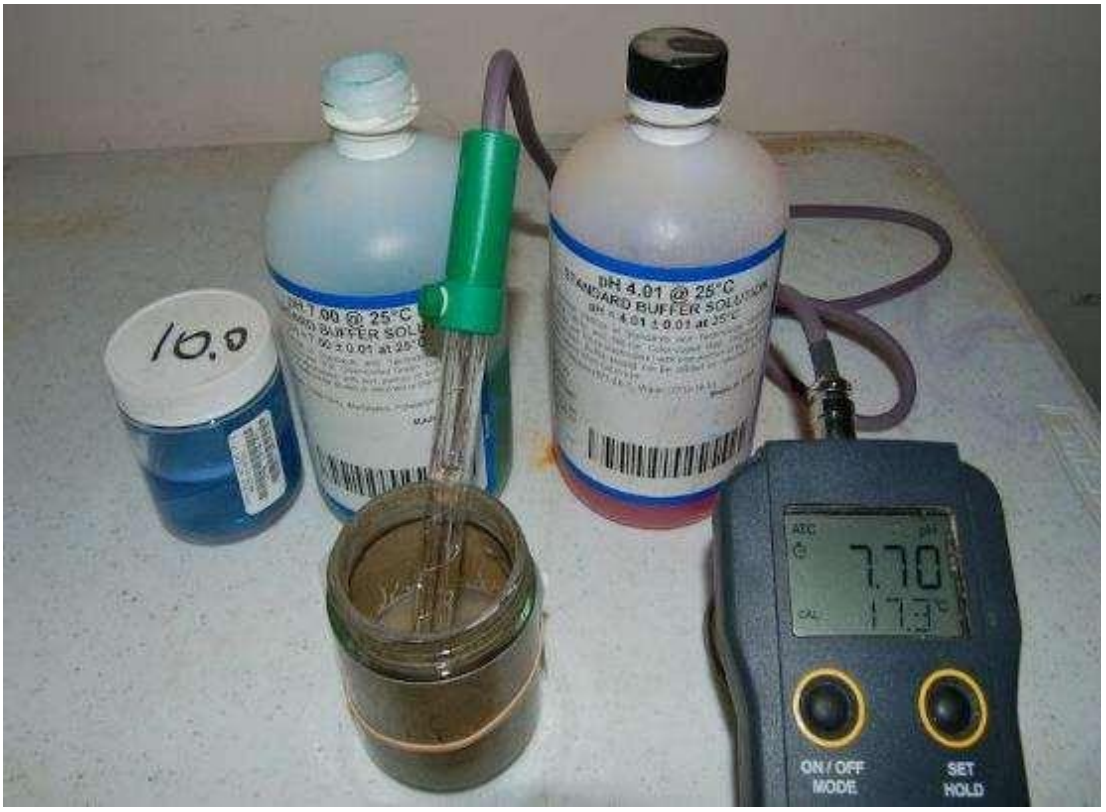
Experiment 1
Determination of pH in water



Introduction:

The term pH refers to the measure of hydrogen ion concentration in a solution and defined as the negative log of H^+ ions concentration in water and wastewater

$$\mathbf{pH} = -\log\{H^+\} \quad \textbf{1.1}$$

Where **$\{H^+\}$** is the concentration (or activity) of hydrogen ion (or photon) in moles per liter (M).

Water dissociates to form hydrogen ion **(H+)** and hydroxyl ion **(OH-)** according to the following equation:

$$\mathbf{\{H_2O\}} = \{H^+\} + \{OH^-\} \quad \textbf{1.2}$$

At equilibrium, we can write,

$$K_W = \frac{\{H^+\}\{OH^-\}}{\{H_2O\}} \quad \textbf{1.3}$$

But, since concentration of water is extremely large (approximately **55.5 mol/L**) and is diminished very little by the slight degree of ionization, may be considered as a constant and its activity is taken as 1.0. Thus Eq. (3) may be written as:

$$K_w = \{H^+\} + \{OH^-\} \quad \textbf{1.4}$$

Where, $\mathbf{K_w}$ = Equilibrium Constant

For pure water at 25 °C, $\mathbf{K_W = 10^{-7} \times 10^{-7} = 10^{-14}}$. This is known as the ion product of water or ionization constant for water. In other words, water (de-ionized or distilled water) at **25°C** dissociates to yield **10^{-7}mol/L** of hydrogen ion **(H^+)** and **10^{-7}mol/L** of hydroxyl ion **(OH^-)**. Hence, according to Equation (1) pH of deionized water is equal to 7.

The values of **pH,** 0 to a little less than 7 are termed as acidic and the values of **pH** a little above **7** to **14** are termed as basic. When the concentration of **H^+** and **OH^-** ions are equal then it is termed as neutral **pH**.

Environmental significance:

Determination of **pH** is one of the important objectives in biological treatment of the wastewater. In anaerobic treatment, if the **pH** goes below **5** due to excess accumulation of acids, the process is severely affected. Shifting of pH beyond **5** to **10** upsets the aerobic treatment of the wastewater. In these circumstances, the **pH** is generally adjusted by addition of suitable acid or alkali to optimize the treatment of the wastewater. **pH** value or range is of immense importance for any chemical reaction. A chemical shall be highly effective at a particular **pH**. Chemical coagulation, disinfection, water softening and corrosion control are governed by **pH** adjustment.

Lower value of **pH** below **4** will produce sour taste and higher value above **8.5** a bitter taste. Higher values of **pH** hasten the scale formation in water heating apparatus and also reduce the germicidal potential of chlorine. High **pH** induces the formation of tri-halomethanes, which are causing cancer in human beings.

Guideline:

According to **Bangladesh Environment Conservation Rules (2023)**, drinking water standard for **pH** ranges from **6.5** to **8.5**.

Principle:

The **pH** electrode used in the **pH** measurement is a combined glass electrode. It consists of sensing half-cell and reference half-cell, together form an electrode system. The sensing half-cell is a thin **pH** sensitive semi permeable membrane, separating two solutions, viz., the outer solution, the sample to be analyzed and the internal solution enclosed inside the glass membrane and has a known **pH** value. An electrical potential is developed inside and another electrical potential is developed outside, the difference in the potential is measured and is given as the **pH** of the sample.

Apparatus:

1. **pH** meter
2. Beaker

Reagent:

1. Buffers Solutions of known pH value

Sample handling and preservation

Preservation of sample is not practical. Because biological activity will continue after a sample has been taken, changes may occur during handling and storage. The characteristics of the water sample may change. To reduce the change in samples taken for the determination of **pH**, keep samples at **4°C**. Do not allow the samples to freeze. Analysis should begin as soon as possible.

Precautions

The following precautions should be observed while performing the experiment:

1. Temperature affects the measurement of **pH** at two points. The first is caused by the change in electrode output at different temperatures. This interference can be controlled by the instruments having temperature compensation or by calibrating the electrode-instrument system at the temperature of the samples. The second is the change of **pH** inherent in the sample at different temperatures. This type of error is sample dependent and cannot be controlled; hence both the **pH** and temperature at the time of analysis should be noted.
2. In general, the glass electrode is not subject to solution interferences like color, high salinity, colloidal matter, oxidants, turbidity or reductants.
3. Oil and grease, if present in the electrode layer, should be removed by gentle wiping or detergent washing, followed by rinsing with distilled water, because it could impair the electrode response.
4. Before using, allow the electrode to stand in dilute hydrochloric acid solution for at least 2 hours.
5. Electrodes used in the pH meter are highly fragile, hence handle it carefully.

Procedure:

Three major steps are involved in the experiment. They are

1. Preparation of Reagents
2. Calibrating the Instrument
3. Testing of the Sample

Steps:

- Perform calibration of the **pH** meter using standard **pH** solutions. The calibration procedure would depend on the **pH** range of interest.
- In a clean, dry **100 mL** beaker, take the water sample and place it in a magnetic stirrer, insert the teflon-coated stirring bar, and stir well.
- Now, place the electrode in the beaker containing the water sample and check for the reading in the **pH** meter. Wait until you get a stable reading.
- Take the electrode from the water sample, wash it with distilled water, and then wipe gently with soft tissue.

Assignment

1. Explain why pH is important in water and wastewater treatment.
2. Define pH in terms of [H+] and [OH-].
3. How much does [H+] decrease if pH increases by 1 unit?
4. At 25 ^{0}C, the hydroxyl ion concentration [OH-] of a solution is $10^{-5.7}$. Determine the pH of the solution.