Experiment

Determination of pH by using glass electrode

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Date: …… **Room Temperature: 28 °C**

Objective

To determine the pH of a given solution by using glass electrode.

Requirements

(a) Apparatus and Glassware: pH-meter with glass electrode, Beaker-100 mL, Volumetric Flask-100 mL.

(b) Chemicals:

- Buffer solutions of pH (7, 4.0, and 9.2),
- Unknown solution (0.01 N HCl).

1. Principle

The pH of a substance is a measure of its acidity (hydrogen ions, H^+, concentration) just as a degree is a measure of temperature. The term pH, introduced by Danish chemist **S. P. L. Sørensen** in 1909, means H^+ exponent and is defined in term of H^+ activity* "*a*". The name, pH, may have come from a variety of sources including: *pondus hydrogenii* (Latin), *potential hydrogène* (French), and *potential of hydrogen* (English). When we measure pH with a pH meter, we are actually measuring the negative logarithm (to the base 10) of the H^+ activity, not its concentration.

$$\mathrm{pH} = -\log a_{\mathrm{H}^+} = \log \frac{1}{a_{\mathrm{H}^+}}$$

$$\text{or} \quad 10^{-\mathrm{pH}} = a_{\mathrm{H}^+}$$

The activity is the effective concentration of hydrogen ions in that solution. It is to be noted that for every decade change in activity, the pH changes by one unity.

In this way, all state of acidity or alkalinity between those of solution with respect to H^+ can be indicated by a series of positive number between 0 – 14. For pure water or a neutral solution, $a_{H^+} = 1 \times 10^{-7}$ mol L^{-1} at 25 °C. Thus a solution for which pH = 7 is neutral, for which pH < 7, is acidic, and for which pH > 7 is an alkaline solution.

*Chemists use the term *activity* to describe quantitatively the effective concentration of participants. Activity is almost the same as concentration in very dilute solutions.

The Glass Electrode:

To determine the pH value or H^+ concentration for a solution, we shall need an electrode reversible to H^+ ions. A pH meter commonly offers a measuring range of 0 to 14. In pH meters, glass electrode is a sensor **(indicator electrode)**, which is sensitive to H^+ concentration in a solution. A glass electrode has an electrode membrane which is made of a special glass with an approximate composition of 6 % CaO, 22 % Na_2O, and 72 % SiO_2. This type of glass has the desirable properties of low melting point, relative high electrical conductivity and a hygroscopic nature for pH measurement. The principle of glass electrode is that when surface of narrow glass is dipped in a solution then potential difference is formed between glass surface and solution, which changes with the H^+ concentration or pH of the solution. The **reference electrode** employed is usually the calomel electrodes but due to mercury toxicity, they have been replaced by safer electrode such as silver-silver chloride [Ag(s), AgCl(s) | Cl^-] electrode.

Glass electrodes are now available as combination electrodes which contain the indicator electrode (a thin glass bulb) and a reference electrode (silver-silver chloride) combined in a single unit as shown in the **Fig. 1.**

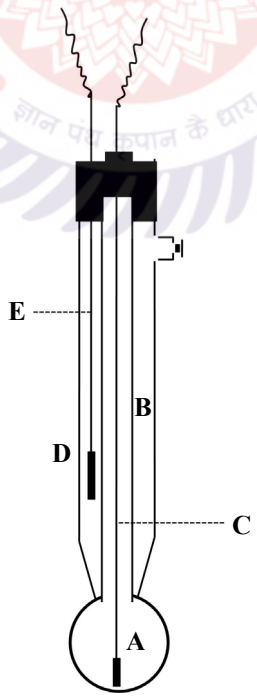
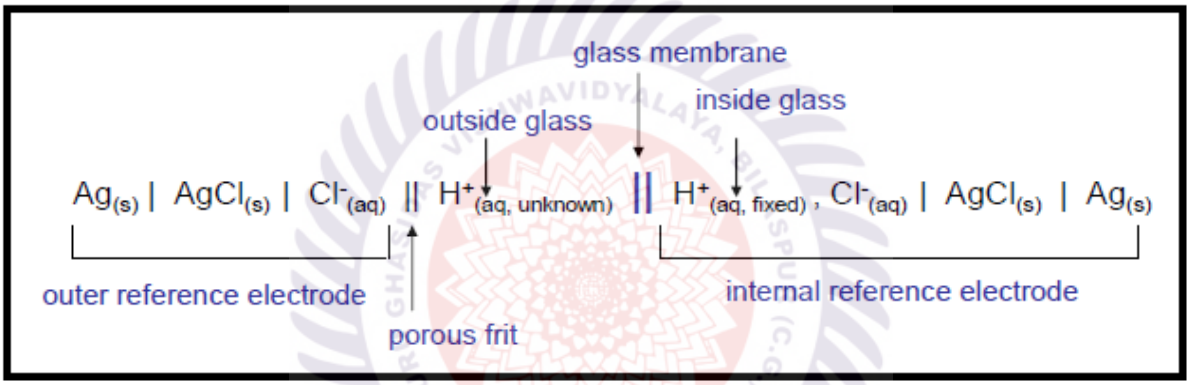


Fig. 1 Glass Electrode

This produces a simple compact unit for immersing in the test solution and has the added advantage that the two cells are in close proximity (with the reference cell normally completely surrounding the sensor element), thus minimizing the effect of any stray electrostatic field or any in homogeneity in the test solution. The thin glass bulb A and the narrow tube B to which it is attached are filled with HCl (normally 0.1 M) and carry a silver-silver chloride electrode C. The wide tube D is fused to the lower end of tube B and contains saturated KCl solution. It carries a silver-silver chloride electrode E. The assembly is sealed with an insulation cap through which the two leads from the electrode are taken. The line diagram of this cell can be written as follows:

$Ag(s), AgCl(s) \mid K^+Cl^- (aq.\ sat.\ sol.) \parallel H^+ (aq.\ outside) \vdots H^+ (0.1\ M)\ (aq.\ inside, Cl^-\ (aq.) \mid AgCl(s), Ag(s)$



2. Solution Preparation

2.1. Buffer Solution: Prepare 4, 7, and 9.2 pH buffer solutions by dissolving of corresponding buffer tablets in distilled water in 100 mL volumetric flasks.

2.2. 0.01 N HCl solution in 100 ml

$$N_1V_1\ (\text{Conc. HCl}) = N_2V_2\ (0.01\ \text{N HCl})$$

$$11.2 \times V_1 = 0.01 \times 100$$

$$V_1 = 0.089\ \text{mL}$$

Take 0.089 mL of concentrated HCl in 100 mL volumetric flask and make upto the mark with distilled water.

3. Procedure

- Calibrate the pH electrode.
- After calibration, rinse electrode and submerge it in the tested solution.
- Read the result and write it down.
- Rinse the electrode and move it to the storage beaker.

4. Calculation

pH of unknown solution (0.01 N HCl) is measured by using glass electrode.

5. Result

The pH of the unknown solution (0.01 N HCl) is found to be **2.051.**

6. Precautions

(i) For long life, electrode should be stored in solution of 4 pH buffer solution.

(ii) Dip the electrode in tap water for 24 hours before first use.

(iii) After 30 minutes of switching on of instrument, work should be performed.

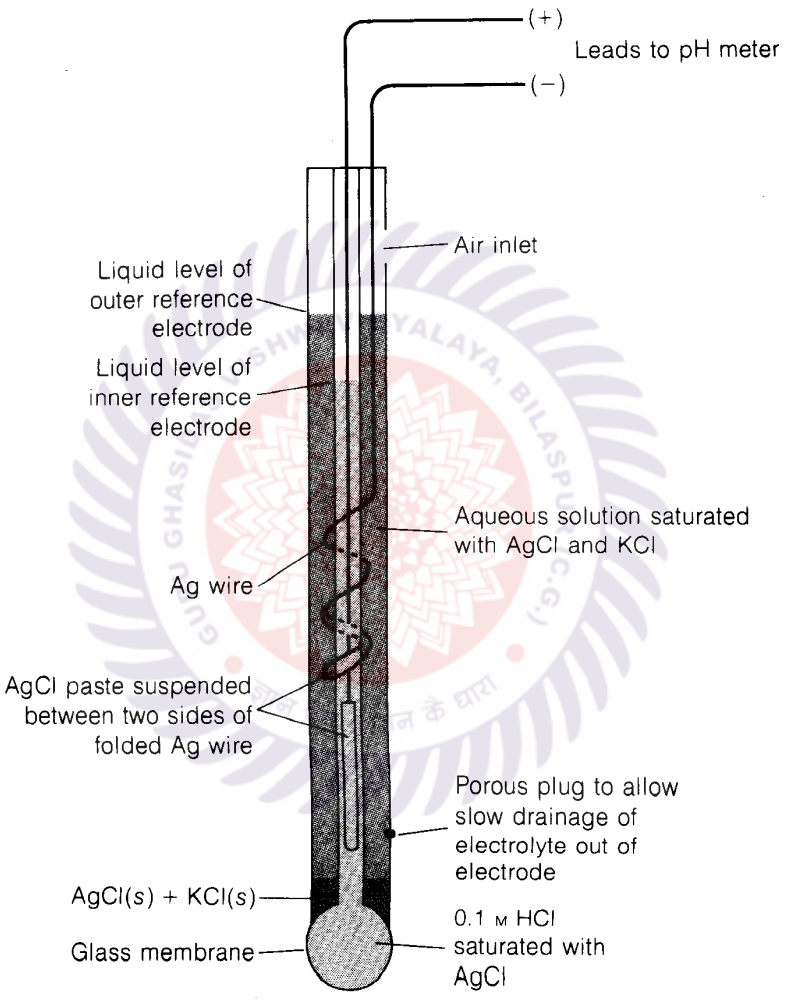
7. Warning

(i) Do not take pH readings above pH 11.5, because high pH damages the glass electrode.

8. Further Reading

- Read up the theory of pH meter and mechanism of the response of pH electrode.
- Ebbing, D. D., *General Chemistry*. 10th ed.; Cengage Learning India Pvt. Ltd.: 2013.
- Elias, A. J., *A Collection of Interesting General Chemistry Experiments*. Revised ed.; University Press: 2007.
- Halern, A. M.; McBane, G. C., *Experimental Physical Chemistry: A Laboratory Textbook*. 3rd ed.; W. H. Freeman and Company: 2006.
- Kapoor, K. L., *A Textbook of Physical Chemistry: Experimental Aspects In Physical Chemistry (SI Units) Volume 7*. 1 ed.; McGraw Hill Education: 2019.
- Puri, B. R.; Sharma, L. R.; Pathania, M. S., *Principles of Physical Chemistry*. 47th ed.; Vishal Publishing Co.: 2018.

APPENDIX


(+)
Leads to pH meter
(−)
Air inlet
Liquid level of outer reference electrode
Liquid level of inner reference electrode
Aqueous solution saturated with AgCl and KCl
Ag wire
AgCl paste suspended between two sides of folded Ag wire
Porous plug to allow slow drainage of electrolyte out of electrode
AgCl(s) + KCl(s)
0.1 M HCl saturated with AgCl
Glass membrane