PH measurement

The pH value is one of the very important characteristics for the course of chemical and especially biochemical events. Depending on the accuracy with which we need to know the pH value, we choose the measurement method. Solutions of acid-base indicators or indicator paper are used for approximate determination, pH meters are used to measure pH with greater accuracy.

Indicator paper for indicative determination of pH

Estimation of pH using acid-base indicators

Some organic compounds change their color depending on the pH of the environment. These are weak acids or bases where the color of the undissociated molecules differs from the color of the ions. We refer to them as acid-base indicators. The area of the color transition is different for individual indicators, the center of the color transition always corresponds to a pH equal to the pK_A of the indicator. We use them in a solution or as pieces of paper impregnated with an indicator solution.

We usually add the indicator solution to a small sample of the investigated solution in the amount of 1-2 drops. After shaking, we assess the color of the solution by comparing it with a table of color transitions or, in the case of mixed indicators, by comparing it with a color scale.

Indicator papers are strips of filter paper impregnated with a suitable indicator or mixture of indicators. In addition to ordinary litmus papers (transition red - blue at pH 5-8), papers with a universal mixture of indicators are produced for the pH range 0-12 or for various narrower pH ranges, where the pH can be determined with an accuracy of tenths of a pH unit. We determine the pH value by comparing the color of the indicator paper after soaking it in the solution with the color scale.

Examples of acid-base indicators

Acid-base indicator	Color transition	pH of the color transition
Methyl Orange	red – yellow	3.0-4.4
Bromothymol blue	yellow - blue	3.0-4.4
Phenolphthalein	colorless - reddish purple	8.2–10.0

Potentiometric measurement of pH

Potentiometric measurement of pH is based on measuring the equilibrium electromotive voltage of a galvanic cell formed by two electrodes immersed in the measured solution. One electrode is a reference electrode with a known constant electrode potential (most often a calomel or silver chloride electrode). The second electrode is an indicator (measurement), whose potential is a function of the activity of hydrogen ions and (H^+), so it depends on the pH.

pH meter

The indicator electrode is a glass electrode. It has the shape of a flask blown at the end of a glass tube and is made of special glass. It is filled with a solution with a known and constant pH value, into which an internal comparison electrode, e.g. silver chloride, penetrates. When the electrode is immersed in the measured solution, a potential difference arises between the outer and inner side of the glass membrane, the size of which is proportional to the pH difference between the measured and inner solution. Since the solution inside the electrode is always the same, the resulting potential depends only on the pH value of the measured solution:

$$E_{\text{ind}} \approx \frac{RT}{nF} \ln a_{\text{H}^+} = \frac{2,3 \cdot 8,314\ \text{J} \cdot 298\text{K}}{1 \cdot 96487\ \text{C}} \log\ a_{\text{H}^+} = -0,059\ \text{pH}\ (V,\ 25°\text{C})$$

From the relationship derived from the Nernst equation, it follows that with a tenfold change in the activity (concentration) of H^+ in the measured solution (which corresponds to a change in pH by one unit) at a temperature of 25 °C detects a change in the electromotive voltage of the entire galvanic cell by 59 mV.

Common pH meters are electronic voltmeters with a large internal resistance that measure with an accuracy of hundreds of pH units; more sensitive devices can achieve ten times greater accuracy, they are used to measure the pH of blood in clinical-biochemical laboratories.

Combined glass electrodes are often used, which also have an external reference electrode built into their shell; both electrodes, glass and comparison, are thus in a single body.

Since the electromotive voltage of the cell (proportional to the hydrogen exponent - pH) depends on the temperature, the perfection of the response of the electrodes and the reliability of the meter, the pH-meter is calibrated before the measurement with at least two solutions of known pH value (buffers).

Links

Related articles

- pH
- pH of strong acids and bases
- pH of weak acids and bases
- pH-metry
- pH of buffers
- Urine pH
- pH of salts

External sources

- Multimediální podpora výuky klinických a zdravotnických oborů. *Návod k praktickému cvičení (pdf, zabezpečený přístup)* [online]. [cit. 2012-11-09]. <http://portal.med.muni.cz/download.php?fid=649>.