MESURMENT OF PH

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pH is defined as the decimal logarithm of the reciprocal of the hydrogen ion activity, $a_{H}+$, in a solution. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. The water molecule has the property of dissociating into two ionic components in aqueous solutions.

$$H_2O <-> H^+ + OH^-$$

The H^+ ion is termed hydrogen ion or proton, the OH^- ion hydroxide ion.

The pH value describes the activity of hydrogen ions in aqueous solutions typically on a scale of 0 to 14. Based on this pH scale, liquids are characterized as being acidic, alkaline or neutral: a solution which is neither acidic nor alkaline is neutral. This corresponds to a value of 7 on the pH scale. Acidity indicates a higher activity of hydrogen ions and a pH measurement value lower than 7. Alkaline solutions are characterized by a lower hydrogen ion activity or higher hydroxide ion activity, respectively and a pH measurement value above 7.

The pH value can be measured using electrochemical measuring systems, litmus paper, or indicators and colorimeters. The easiest way to take a pH measurement is to use litmus paper or a colorimeter. The advantage of this type of pH measurement is that the pH range is well known and they are easy to apply. Unfortunately in many cases litmus paper and colorimeters are not accurate enough to make high quality pH measurements, because the pH value transition point depends on the user.

Another pH value measurement possibility is amperometry. The advantage of amperometry as a pH measurement method is that it is simple to use. In amperometric pH measurements hydrogen generation occurs on a noble metal. When combined with a less noble metal a power distributing galvanic cell is formed. Because hydrogen ions are generated the cell's current depends on the pH value. The disadvantages of this method is that differences in the sample composition create very large errors in pH measurements and the method cannot deliver dependable results in extremely concentrated acids and bases due to effects related to the pH glass membrane.

In special cases the pH value measurement can be made using conductometry (conductivity measurement). With this pH measurement method any membrane effects are minimized because of the measurement technique. The advantage of this pH measurement method is that it is relatively easy to use. The disadvantage is that a conductivity measurement measures all

ion activity not just hydrogen ion activity. Additionally this pH measurement is only reproducible and safe at low ion concentrations.

A relatively new method for pH value measurement is the use of an ion selective field effect transistor (ISFET). Briefly the ISFET is a transistor with power source and drain, divided by an isolator. This isolator (gate) is made of a metal oxide where hydrogen ions accumulate in the same way as an electrode. The positive charge that accumulates outside the gate is 'mirrored' inside the gate by an equal negative charge generates. Once this happens the gate begins to conduct electricity. The lower the pH value the more hydrogen ions accumulate and the more power can flow between source and drain. The ISFET sensors, similar to glass pH electrodes, act according to the Nernst equation. The advantage of an ISFET is that they are very small. The actual field effect transistor is only 0.2 mm^2. The disadvantage of using an ISFET for pH measurements is that they have comparatively short durability and low long-term stability with a typical use life cycle being in range of weeks.

The most common method of pH value measurement is the use of pH measurement electrodes, like the IoLine series from SI Analytics. These pH measurement devices are electrochemical sensors which consist of a measuring electrode and a reference electrode. The pH measurement electrode is made of special glass which, due to its surface properties, is particularly sensitive to hydrogen ions. The pH measurement electrode is filled with a buffer solution which has a pH value of 7. When

placing the pH measurement electrode into a test solution, the change in voltage is measured by the pH electrode by comparing the measured voltage to the stable reference electrode. This change is recorded by the pH meter, such as the pH3110 Field pH Meter, Lab 850 Benchtop pH Meter, or ProLab 1000 Professional Bench Top pH Meter, and converted into the pH measurement value displayed.