

pH measurement & control

Instrumentation through innovation

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SPECIAL POINTS OF INTEREST:

Brönsted definition of acid & bases

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A bio-technology news letter

Hydrogen Ion concentration which is generally termed as pH is an important factor in Bio Engineering and bio processes. In many cases slight variation of the pH results in changes in growth process and in some cases effects process kinetics. Most of the bio processes and cell culture products use buffered mediums so that the pH does not change drastically. The insitue measurement and addition of appropriate reagent to restore the pH to the set level is built in to the system engineering.

Substances that dissociate in aqueous solutions with splitting up of protons (H^+) are called acids.

Similarly substances which can split off Hydroxyl Ion (OH^-) are called bases.

This definition does not satisfy consideration of neutralization reactions and the most accepted definition is suggested by **Brönsted**.

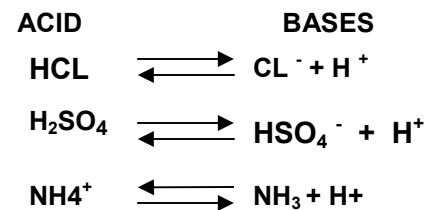
As defined by Bronsted in 1923 acids are systems which can donate protons (i.e.,) in principle all hydrogen compounds can act as acids, Molecular acids HCL, H_2SO_4 , HNO_3 , CH_3COOH etc. Ionic acids, which are again, subdivided as cationic NH_4^+ and anionic HSO_4^- .

Similarly bases are systems which can accept protons neutral molecules NH_3 , H_2O as well as anions can act as bases. Proton transfers are reversible: Every system can therefore reaccept proton after donating or after accepting protons, can re-donate again.

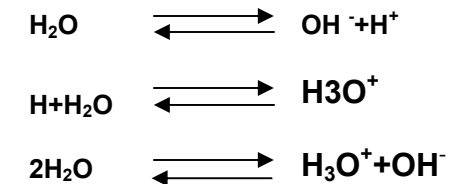
Thus by donating proton an acid becomes a base and by accepting protons a base becomes an acid.



Examples:

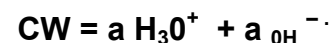


To understand the acid base behavior of water is of special interest since the quantum of water consumed in a bio-reaction is phenomenally high. Also water plays a vital role in bioprocesses, to maintain homogeneity, solubility, mixing and providing food and nutrition to cells while they grow.



Water acts both as a proton donor (acid) and proton acceptor (base) such compound is called impolite.

On application of law mass of action



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It is strongly Temperature dependent, at 22°C the value is 10^{-14} in pure water. Since water is neutral the amount of acidic and basic ions are equal.

$$a_{H_3O^+} = a_{OH^-} = \sqrt{K_w} = 10^{-7}$$

The pH value or proton activity exponent is defined as the negative common logarithm of the proton activity which in aqueous solutions is equal to the activity of the hydronium ions.

Pure water has therefore a pH of 7.00 at 22°C. Solutions with pH <7 are termed as acids and those with pH >7 as bases. The normal pH scale for aqueous system extends from 0-14. Substances that are below 0 and above 14 are strongly acidic and basic respectively.

Knowledge of the strength of acid and base is important in chemistry and Bio-fields since small changes in pH adversely affect the cell life and growth. In case of bio-chemistry/bio processes determination of pH, control of pH, monitoring the rate of change of pH with respect to growth and or chemical/bioactivity is very important. Where ever possible the medium is prepared with adequate buffers so that changes in pH are minimum. Also the constituents of the buffered medium is dynamically adjusted by controlled addition using peristaltic pumps.

A pH sensor utilizes a robust industrial electrode for field monitoring in a variety of environments.

The pH electrode consists of a pH sensitive glass membrane sealed for a glass insulating tube containing a solution of fixed pH in contact with a silver chloride half cell that serves as a reference electrode. Another such electrode is the calomel electrode. The potential developed across the membrane is compared to a stable reference potential of silver chloride half cell in contact with electrolyte containing chloride. The circuit is completed by means of a porous constriction which allows the reference electrolyte to slowly flow into the sample. Thus the signal developed is a measure of the pH of the medium.

Also pH is temperature dependent and the temperature compensation curve is defined by the equation.

$$\frac{RT}{F} \log_{10} (H^+)$$

Where ...

R = 8.3143 universal gas constant

F = 9.6487 faraday constant

T = absolute temp. is $0^{\circ} + 273.15$

Most of the pH measuring instruments will have a PT – 100 temperature, probe and the pH drift due to change in temperature is automatically compensated.

Note: An important consideration with using a pH sensor in field measurements in the likely hood of errors due to earth loops with other sensors. The pH electrode has high input impedance, typically 10 – 12MΩ. And even small stray electrical currents can cause very large errors in the out put reading unless special precautions are taken.

The signal path is to be isolated using the latest balanced optical isolation techniques to ensure that there is no signal path from the electrode to the common power supply.

Control methodology:

Normally low/high set point controls are employed in conjunction with valves and pumping devices so that once the error signal between the set point and the actual value reaches zero the action is complete. This is to be used only when the dead band that can be tolerated is high.

In case of more precise control application the concentration of the reagent to be added and or the flow rate (i.e.,) the quantum of addition is to be dynamically controlled.

In our next issue:
DO and its control

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