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Buffer-pH and Acid-Base Balance

Introduction

- **In normal water (non-buffered solution) if you add a small amount of a strong acid or base, it will cause the pH of the water to change significantly. Two drops of 1 mol dm^{-3} HCl added to water will change the pH from 7 to 4.**

- **Most chemical reactions occurring in our bodies work best in a specific pH range. Blood, for example, works at pH 7.4 and any variation of 0.2 units either way would render the person seriously ill.**

- **A buffer solution can be described as a solution, which will resist changes in pH when a small amount of a strong acid or base is added.**

- **Buffer solution is a mixture of both weak acid and a salt of this acid *OR* a weak base and a salt of this base. It is important in the body because they maintain the acid-base balance in the blood.**

Buffer solutions are important living things because if the pH of cellular fluids is not maintained at certain critical levels the plant or animal could die.

- **buffer solutions are a mixture of substances that interact with any incoming acid or alkali impurity to render them ineffective and help restore the pH of the solution to its original value.**

- **To make sure the pH values are kept at the appropriate best working values, our body cells employ a series of solutions called ‘buffers’. These are molecules that resist any changes of acidity or alkalinity.**

Buffers in the body

Protein buffers

- **Proteins are the most abundant materials in the body. Proteins have long chains of carbon compounds, as many as 1000 or more, and have amino acid side chains sticking out of them. One protein of general formula could be $^{+}NH_3(CH_2)_nCOOH$:**

$$^{+}NH_3(CH_2)_nCOOH \overset{+H^+}{\rightleftharpoons} NH_2(CH_2)_nCOOH \overset{-H^+}{\rightleftharpoons} NH_2(CH_2)_nCOO^{-}$$

- ***An adverse external influx of acids could be removed by the protein buffer soaking up the H^+ ions to form a positive ion, hence restoring the original pH. If OH ions are present, these react with the buffer, causing the amino acid or protein to make H^+ ions. These react with the hydroxide ions to form neutral water. More of the protein will ionize if more OH^- ions are added as an impurity. The above equilibrium moves to the right and the original pH is restored.***

- **Haemoglobin (a compound of iron and proteins) buffers the blood system using the proteins present. This is essential for controlling the pH of the blood, which is necessary due to the uptake of acidic CO2 gas formed when cells use carbohydrates, glucose, to give energy.**

- **The most important pH buffer system in the blood involves carbonic acid (a weak acid formed from the carbon dioxide dissolved in blood) and bicarbonate ions (the corresponding weak base).**

Equimolar of $CH_3COOH_{(aq)}$ + $CH_3COONa_{(aq)}$

- **If small amount of strong acid is added it will react with conjugated base as the following:**

$$H_3O^+ + CH_3COO^- \rightarrow CH_3COOH + H_2O$$

- **The equilibrium will lie to right, so most of H^+ added will be removed from the solution & the pH will hardly be damaged.**

What if OH^- is added?

$$OH^- + CH_3COOH \rightarrow CH_3COO^- + H_2O$$

- **So again the equilibrium will lies to the right. Consequently most of hydroxide ions will removed from the solution and the pH will slightly changed.**

- **The blood's acid-base balance is controlled by the body because even minor deviations from the normal range can severely affect the brain, arteries, the heart, muscles, and many organs. It can contribute to overwhelming the body leading to serious disease such as cancer.**

Henderson-Hasselbalch Equation For Buffer Solutions

- **The pH of buffer solution could be calculated as the following:**

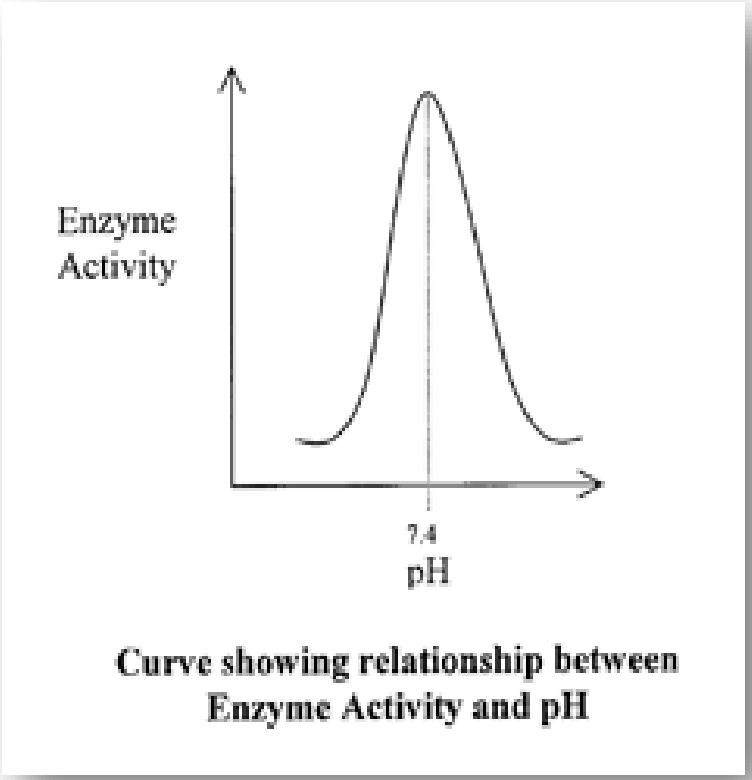
$$pH = pK_a + \log \frac{[\text{conjugate base}]}{[\text{weak acid}]}$$

- **Small changes in the concentration of either acetate or acetic acid will hardly change the pH.**

The Importance of Hydrogen Ion Concentration

- **Hydrogen ion concentration has a widespread effect on the function of the body's enzyme systems. The hydrogen ion is highly reactive and will combine with bases or negatively charged ions at very low concentrations.**

- **Proteins contain many negatively charged and basic groups within their structure. Thus, a change in pH will alter the degree ionization of a protein, which may in turn affect its functioning. The figure below shows the relationship between enzyme and the pH.**



Curve showing relationship between Enzyme Activity and pH

Acid-Base Balance

- **Blood is normally slightly basic, alkaline, with a pH range of 7.35 to 7.45. To function properly, the body maintains the pH of blood close to 7.40.**

Acidosis and Alkalosis

- **There are two abnormalities of acid-base balance.**
- **Acidosis: The blood has too much acid (or too little base), resulting in a decrease in blood pH.**
- **Alkalosis: The blood has too much base (or too little acid), resulting in an increase in blood pH.**

Two Factors That Contribute to Blood pH Imbalance

- **The first is our intake, oxygen-carbon dioxide, and dietary habits.**

- **The second is our production, elimination, and stress.**

- **Any acid reacts with HPO_4^{-2} according to the following equation:**

$$HPO_4^{-2} + H_3O^+ \leftrightarrow H_2PO_4^- + H_2O$$

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- **While any base will react with $H_2PO_4^-$ as depicted below:**

$$H_2PO_4^- + OH^+ \leftrightarrow HPO_4^{-2} + H_2O$$

- **$[HCO3^-]$ / $[H_2CO_3]$ < 20:1 --- Acidic (when the blood become acidic: Acedimia).**

- **$[HCO3^-]$ / $[H_2CO_3]$ > 20:1 --- Alkalimia**

Death occur if blood pH < 6.8 or pH > 7.8

Good acid-base balance and blood pH levels promote:

- Healthy cholesterol levels.
- Healthy blood sugar balance.
- Proper fat metabolism.
- Normal energy balance.
- Disease resistance.
- The body's ability to flush toxins.

Thank You