The Acid Base Balance : Controlling pH of Body Fluids

What is the meaning of pH?

The term ph is a symbol used to mean the hydrogen ion (H+) concentration of a solution and it indicates the acidity and alkalinity of the solution.

An acid is a substance that dissociates to produce more hydrogen ions than hydroxyl ions.
A base is a substance that dissociates to produce more hydroxyl ions than hydrogen ions.

Sources of ph influencing elements.

Both acid and base continually enter the blood from observed food and from the metabolism of nutrients of cellular levels.
Therefore some kind of mechanism of neutralizing or eliminating these substances is necessary if the ph is to remain constant.

Although both acid and basic components are important, the homeostasis of body ph largely depends on the control of hydrogen ion concentration in the extracellular fluid.

Hydrogen ions continually enter the body from carbonic and lactic acid produced by both aerobic and anaerobic respiration of glucose, and acid ketone bodies from the incomplete breakdown of fats and phosphoric acid which accumulate when certain proteins are broken down.

Base forming such as fruits and vegetables contains minerals elements such as potassium, calcium, sodium, and magnesium which continually add bases into the body.

Types of PH control mechanisms

Type	Response time	examples
Chemical, buffer systems	rapid	Bicarbonates buffer systems, phosphates buffer systems, and Proteins buffer systems
Physiological buffer systems	delayed	Respiratory response systems and Renal response systems

The rapid-acting chemical buffer system immediately combined with any added acid or alkali that enters the body fluids and thus prevents drastic changes in the ph concentration.

If the immediate action of a chemical buffer cannot stabilize the ph, the physiological buffers serve as a secondary defense against the harmful shift, ph shifts that are not halted by immediate effect of chemical buffering cause the respiratory system to respond in 1 to 2 minutes and changes in the rate and depth of breathing will occur.

If the respiratory mechanisms are unable to stop the pH shift a more powerful but slower-acting renal physiological buffer system involving excretion of either acid or alkaline urine will be stimulated.

Buffer Mechanisms for controlling pH of body fluids

A buffer is a substance that prevents marked changes in the pH of a solution when an acid or base is added to it.

Most of the body fluid buffer pairs consist of a weak acid and a salt of that acid for example

1. Bicarbonate pairs $NaHCO_3/H_2CO_3$ and $KHCO_3/H_2CO_3$

2. Plasma protein pair Na, proteinate/Protein (weak acid)

The action of buffers to prevent marked changes in the pH of body fluids.

Buffers react with a relatively strong acid or base to replace it with a relatively weak acid or base. That is an acid that highly dissociates to yield many hydrogen ions is replaced by one that dissociates less to yield fewer hydrogen ions.

Thus by the buffer reaction instead of the strong acid remaining in the solution and contributing many hydrogen ions, drastically lower the ph of the solution a weak acid takes its place, contributes fewer additional hydrogen ions to the solution and thereby lowers its ph only slightly, since blood contains buffer pairs its ph fluctuates less widely than it would without them. in other words, blood buffers constitute one of the devices that prevent marked changes in the blood ph.

Physiologic Buffer Systems

1. Respiratory response system
2. Renal response system

Respiratory regulation of acid-base balance

The main action is to control the acid-base balance of the extracellular fluid by the lungs. An increase in ventilation eliminates carbon (iv) oxide from the extracellular fluid which by mass action reduces the hydrogen ions concentration.

Conversely, decrease ventilation increases carbon (iv) oxide thus increasing hydrogen ions concentration in the extracellular fluid.

Whenever the hydrogen ions concentration above the normal the respiratory system is stimulated and alveolar in ventilation increases thus decreasing PCO_2 in the extracellular fluid and reduces hydrogen concentration back towards normal of 7.35.

When the hydrogen concentration below normal, the respiratory centers become depressed, alveolar ventilation decreases and hydrogen ion concentration falls towards normal. This kind of buffering system is physiological because it’s rapid and keeps hydrogen concentration from changing too much before slowly responding kidneys can eliminate. It is 2 to 3 times greater than

chemical buffering in extracellular fluid.

Renal control of acid-base balance

Kidney control acid-base balance by excreting acidic or basic urine.

It excretes as follows:

Hydrogen carbonates ions are filtered continuously into tubules removing the base.
Large numbers of hydrogen ions are also excreted into tubules lumen by tubular epithelial cell thus removing hydrogen ions from the blood making it less acidic.

If more hydrogen ions are secreted than hydrogen carbonates filtered, there will be a net loss of acid from the extracellular fluid. Conversely, if more hydrogen carbonate ions are filtered than hydrogen ions secreted there will be a net loss of basicity.

80 milliequivalent of nonvolatile acid must be secreted each day from protein metabolism excreted by the lung thus the kidney regulates extracellular fluid hydrogen ion concentration through there fundamentals mechanism: secretion of hydrogen ions, reabsorption of filtered hydrogen carbonates ions and production of new hydrogen carbonates.

When hydrogen ions are secreted into the tubular lumen, filtered bicarbonates ions are reabsorbed into the blood,80 to 90%bicarbonates reabsorption takes place at the proximal tubule,10% at a thick ascending loop of Henle and the remaining takes place at collecting duct and distal tubule.

Hydrogen ions are secreted by secondary active transport at early tubular segments using sodium hydrogen counter transport and primary active transport of hydrogen ions intercalated each of late distal and collecting tubules using hydrogen transporting ATPase.

A combination of excess hydrogen ions using phosphate and ammonia buffers in the tubule will lead to a generation of new bicarbonate ions.

Factors that increase or decrease hydrogen ions secretion and hydrogen carbonates reabsorption by renal tubules are:
Carbon (IV) oxide, extracellular fluid volume, aldosterone, hypokalemia, and angiotensin (ii).