**Acid-Base Balance**

**Chemistry, Anatomy, or Biology**

The human body is maintaining an intricate balance of many chemicals and many of these affect pH balance. This worksheet will explore pH using various patient scenarios. Of course pH change is related to and affected by many biological processes. The human body is constantly maintaining that delicate balance between many chemical reactions and processes through metabolism. When one of those metabolic pathways is not working properly a person can quickly become ill and not survive the imbalance.

The normal pH for human blood is within a set-point range of 7.35-7.45 and maintained by three defense mechanisms. These systems include the bicarbonate buffer system, the respiratory system, and the renal system. To understand the relationship within the body between chemical processes and pH consider that an endless supply of hydrogen ions is available and how many hydrogen ions are released affects the systemic pH.

The bicarbonate buffer system is a process that occurs in a fraction of a second taking up and releasing hydrogen ions to maintain the narrow set point range. The process has been described as a “chemical sponge”.

The respiratory system plays a key role in acid-base regulation. This system is slower than the bicarbonate buffer system and uses respiratory centers in the brain to change the rate and depth of respiration when the carbon dioxide (CO2) or hydrogen ion (H+) levels increase significantly. When pH returns to normal the respiratory center returns the rate and depth of respiration back to normal.

The renal system is much slower and can take hours to days to affect the hydrogen ion concentration. Therefore, it is very important in long-term maintenance of acid-base balance.

H2CO3

1

Carbonic Acid

HCO3-

20

Bicarbonate

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The Bicarbonate Buffer System

CO2 + H2O H2CO3 H+ + HCO3-

(carbon dioxide + water yields carbonic acid which yields hydrogen ion + bicarbonate)

A person exhales CO2 as a by-product of cellular respiration and humans are composed of about 60% water. If you do not exhale at the normal rate the amount of CO2 in your blood will increase and affect your pH. Inversely, if you exhale too much as in hyperventilation, your pH is affected. So think through the process and use your chemistry to understand anatomy or anatomy to understand chemistry. If a person’s breathing rate slows down and CO2 builds up then the amount of carbonic acid increases and that increases the amount of hydrogen ions.

Ok, now someone starts to hyperventilate or breathe too fast. Now the amount of CO2 is decreasing so not as much carbonic acid so less hydrogen ions are formed.

There are different types of acidosis and alkalosis that occur in the human body. One is the result of a change in the respiratory system and the other results from a change in metabolism. The connection between cellular respiration and acidosis is related to the break down of proteins instead of glucose.

Any chemical that affects the central nervous system, particularly the brain stem respiratory center, can have an affect on the respiratory rate and affect the pH. For instance aspirin is a salicylate and can cause toxicity if taken in excess and can affect the central nervous system. Another clinical feature of aspirin toxicity is the uncoupling of the oxidative phosphorylation system, causing a massive increase in oxygen consumption, metabolic rate, and disrupts normal glucose utilization. This dramatically increases lactic acid and ketone production.

What happens when something other than glucose is used in cellular respiration? This is where that delicate metabolic balance is tilted and the result can be deadly. The body normally uses glucose to produce ATP but a diabetic person can develop diabetic ketoacidosis (DKA) and this is a life-threatening problem. It occurs when the body cannot use sugar (glucose) as a fuel source because there is no insulin or not enough insulin. Fat is used for fuel instead. When fat is broken down to fuel the body, chemicals called ketones (acids) build up in the body.

Here are three cases that will help you see the relationship between physiology, chemistry, metabolism, and homeostasis within the human body. You may need to refer to your text to supplement the above information. Respiratory rate is the number of breaths taken per minute.

Case 1

Parents cannot awaken a 15-year-old female with a history of diabetes. She is unconscious and is breathing very fast at a rate of 40-50 breaths/minute (normal is 12-20/min). When EMS arrives they find that her blood glucose level is so high that the instrument, a glucometer, reads “HIGH”.

Case 2

A 18-year-old male with a history of IV drug abuse is found unconscious by his parents in his room. He is breathing very slowly at 4 breaths/min and he is cyanotic (has a bluish skin color due to lack of oxygen).

Case 3

An 80-year-old male with a history of dementia, coronary artery disease and arthritis is found on the floor having a seizure. He mistakenly used some oil of wintergreen (methyl salicylate) as a mouthwash. The oil of wintergreen was being used by his wife as a topical treatment for her arthritis and was placed by his mouthwash in the bathroom. His seizure was brief and he is unconscious, hot to the touch with a fast respiratory and heart rate. His glucose level is 47 mg/dl, normal value for non fasting is below 125 mg/dl. His skin is hot and dry and there are not signs of trauma.

**Answer the following questions**

1. What is the role of a buffer system?
2. What scale do we use measure the hydrogen ion concentration on the blood?
3. If there are more hydrogen ions blood pH will increase or decrease?
4. If there are less hydrogen ions blood pH will increase or decrease?
5. The normal value for a blood pH is slightly \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_(acidic or basic). The normal value is between \_\_\_\_\_\_\_\_\_\_\_ and \_\_\_\_\_\_\_\_\_\_\_\_\_.
6. Rank the three buffer systems used by the human body in order of how quickly they work from quickest to slowest.
7. What is the normal respiratory rate for an adult? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. What gas is exhaled when we breathe? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
9. List the ions in the body associated with the bicarbonate buffer system? \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
10. Define a strong electrolyte and a weak electrolyte.
11. In aspirin toxicity what occurs as a result of the uncoupling of the oxidative phosphorylation system? (Make sure you address pH)
12. Hyperventilation causes respiratory \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, while hypoventilation causes respiratory \_\_\_\_\_\_\_\_\_\_\_\_\_\_. Explain the relationship between respiratory rate and pH in your own words.

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