Acids, Bases, Salts, Buffers

Acids, Bases, Salts, Buffers

- An acid is any solute that dissociates in a solution and releases hydrogen ions, thereby lowering pH
  - Since a hydrogen ion consist solely of a proton, an acid is referred to as a proton donor
  - A strong acid dissociates completely in a solution and occurs essentially in one direction
    - $HCl + aq \rightarrow H^+_{(aq)} + Cl^-_{(aq)}$
  - A weak acid fails to dissociates completely and a significant number of molecules remain intact at equilibrium
    - $H_2CO_{3(aq)} \leftrightarrow H^+ + HCO_3^-$

Acids, Bases, Salts, Buffers

- A base is a solute that removes hydrogen ions from a solution, acting as a proton acceptor
  - In a solution, many bases release OH- (hydroxide ion)
  - Hydroxide ions have a strong affinity for H+ and react quickly with them
  - The same terminology applies to strong and weak bases
    - $NaOH_{(s)} + aq \rightarrow Na^{+}_{(aq)} + OH^{-}_{(aq)}$
    - $NH_{3(aq)} + H_2O \leftrightarrow NH_4^{+}{}_{(aq)} + OH^{-}_{(aq)}$

Acids, Bases, Salts, Buffers

- A salt is an ionic compound consisting of a cation except a hydrogen ion and an anion except a hydroxide ion
  - A salt is the product of acid-base neutralization, In general acid + base → salt + water
- Buffers are compounds that stabilize pH of a solution by removing or replacing hydrogen ions
  - Buffer systems typically involve a weak acid and its related salt, which functions as a weak base

Salts

- A salt is an ionic compound consisting of a cation except a hydrogen ion and an anion except a hydroxide ion
  - A salt is the product of acid-base neutralization
  - In general acid + base → salt + water
    - $NaOH + H_2CO_3 \leftrightarrow NaHCO_3 + H_2O$
    - Carbonic acid (H_2CO_3) and Sodium Bicarbonate ($NaHCO_3$) are essential in the carbonic acid-bicarbonate buffer system
      - Buffers typically involve a weak acid (such as carbonic acid) and a related salt (such as sodium bicarbonate)

pH

- A hydrogen atom involved in chemical reactions can easily lose its electron to become a hydrogen ion, H^+
- Hydrogen ions are extremely reactive in solutions and in excessive numbers they can break chemical bonds, change the shapes of molecules and disrupt cell and tissue functions
  - As a result, H^+ must be regulated precisely

pH

- A few H^+ are present in water
  - $H_2O \leftrightarrow H^+ + OH^-$
  - Very few water molecules ion and the number of hydrogen and hydroxide ions is extremely small
  - One liter of pure water has 0.0000001 mol of hydrogen ions
  - This can be written as $[H^+] = 1 \times 10^{-7}$mol/L
    - The brackets indicate the "concentration of"
    - pH is a shorthand to indicate this
    - The pH scale is logarithmic, meaning that each decrease in number is actually 10 times greater in H^+ concentration
      - pH 6 - $[H^+] = 1 \times 10^{-6}$mol/L or 0.000001 mol/L
      - ph 5 - $[H^+] = 1 \times 10^{-5}$mol/L or 0.00001 mol/L
      - ph 4 - $[H^+] = 1 \times 10^{-4}$mol/L or 0.0001 mol/L
      - ph 8 - $[H^+] = 1 \times 10^{-8}$mol/L or 0.00000001 mol/L
- Acids have a lower pH number (more hydrogen ions) and Bases have a higher pH (less hydrogen ions)

Buffers and pH Regulation

- pH regulation is essential for homeostasis in the body
  - Blood, for example, must be kept in the pH range of 7.35 – 7.45
    - Acidosis is a condition of blood pH below 7.35
    - Alkalosis is a condition of blood pH above 7.45
    - Both conditions can be fatal
- Most metabolic processes create excess H+

Buffers and pH Regulation

- The body temporarily ties up excess H+ in buffers, excretes H+ via the kidneys in the urine, and permanently ties up H+ via the removal of CO_2 at the lungs
- Buffers are therefore the first line of defense and the respiratory and renal mechanisms are the second
  - The body has three major buffer systems
    - The protein buffer system
      - Contributes to pH regulation in ICF and ECF
      - Amino acids can either release a H^+ or remove a H^+
    - The phosphate buffer system
      - Buffers ICF and urine
    - The carbonic acid-bicarbonate buffer system
      - The most important buffer system, we will look at this further

Volatile Acids, Fixed Acids, and Organic Acids and pH Balance in the Body

- The body contains three general categories of acids
  - Volatile acids
  - Fixed acids
  - Organic acids

Volatile Acids, Fixed Acids, and Organic Acids and pH Balance in the Body

- Volatile acids
  - Acids can leave a solution and enter the atmosphere
    - Carbonic acid (H_2CO_3) is an important volatile acid, as it breaks down in the lungs to $CO_2 + H_2O$, the CO_2 diffuses into the alveoli and leave during expiration
    - In tissues, CO_2 can interact with water to form carbonic acid which dissociates to release hydrogen ions and bicarbonate ions
    - $CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$
      - » This is the carbonic acid-bicarbonate buffer system
      - » In effect, it can take excessive H+ released from fixed acids or organic acids and generate volatile acids which can be eliminated at the lungs
      - » The amount of CO_2 in the blood is inversely related to pH (more CO_2 = lower pH d/t increase in H^+, less CO2 = increase pH d/t less H^+), therefore breathing de-acidifies the body

Volatile Acids, Fixed Acids, and Organic Acids and pH Balance in the Body

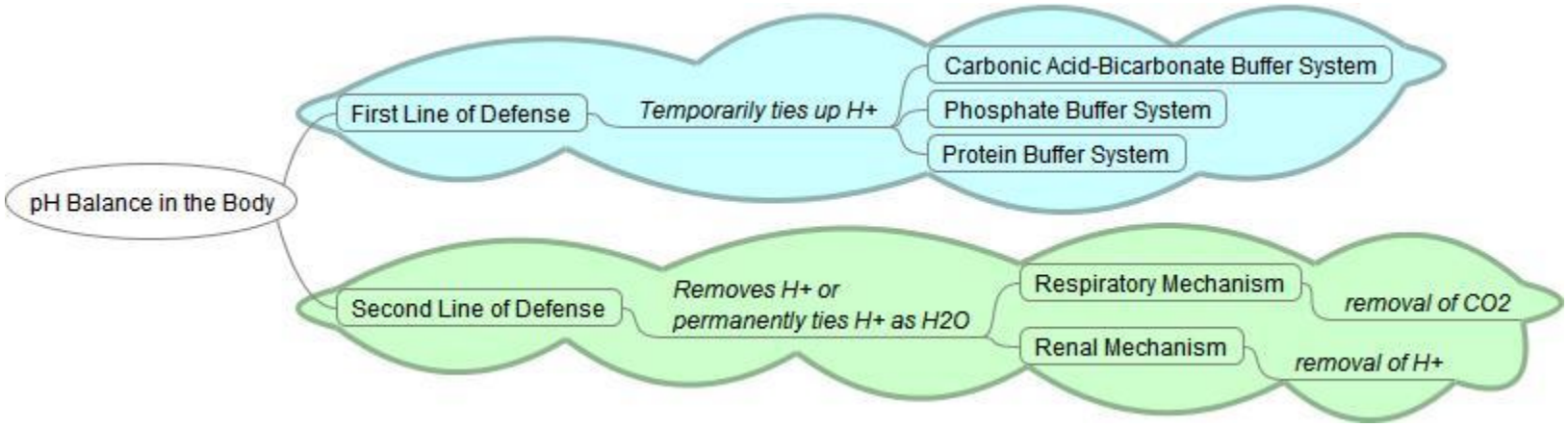
- Fixed acids
  - Acids that do not leave solution
  - In the body, these acids stay in the body fluids until they are eliminated at the kidneys
  - Includes acids that are formed from the catabolism of amino acids, phospholipids and nucleic acids

Volatile Acids, Fixed Acids, and Organic Acids and pH Balance in the Body

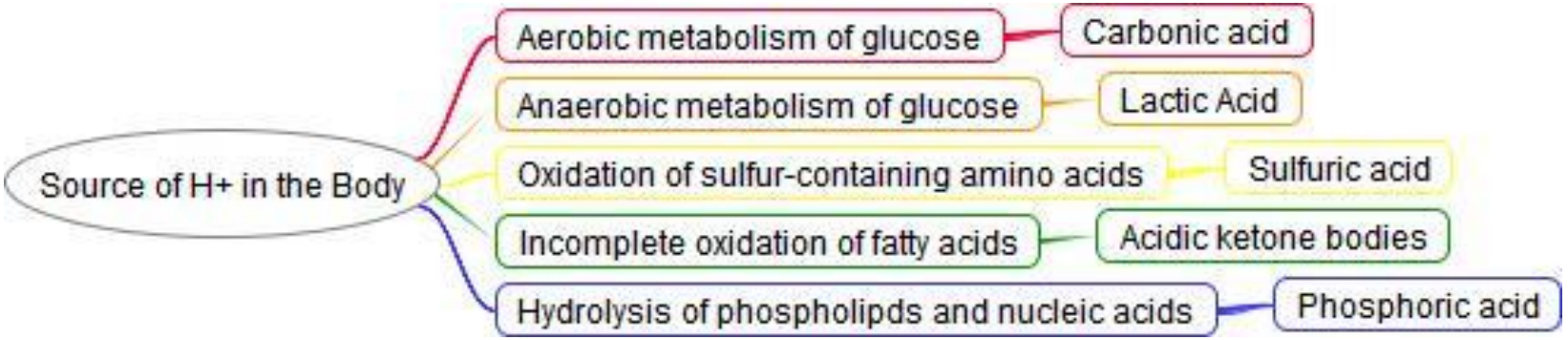
- Organic acids
  - Acid participants in or by-products of aerobic metabolism
  - Lactic acid and ketone bodies are examples
  - Most organic acids are metabolized rapidly, but they can build up during certain circumstances

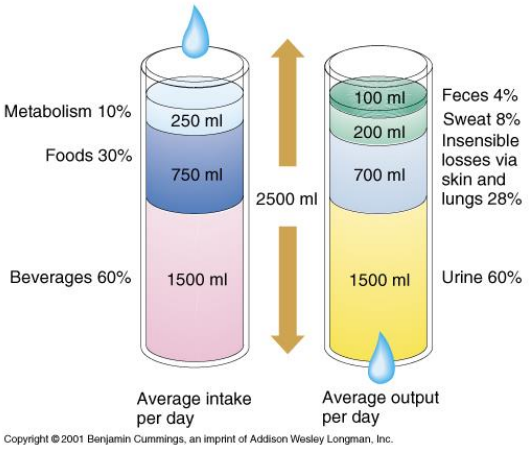
Maintenance of Acid-Base Balance

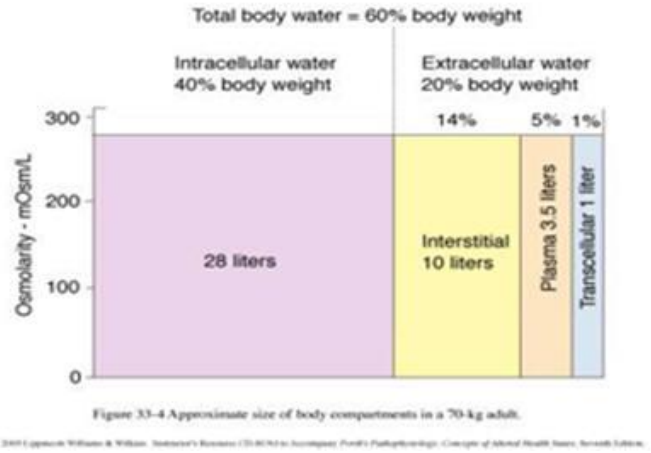
- Buffers resist changes in pH
  - Most often, body processes cause a decrease in pH
  - Buffers can resist this because they can tie up H^+, but eventually the body needs to remove H^+
  - This can be accomplished two ways
    - The H^+ can be either permanently tied up as H_2O by removal of CO_2 at the lungs (carbonic acid-bicarbonate buffer system)
    - H+ can be secreted from the body fluids at the kidneys and removed with urine

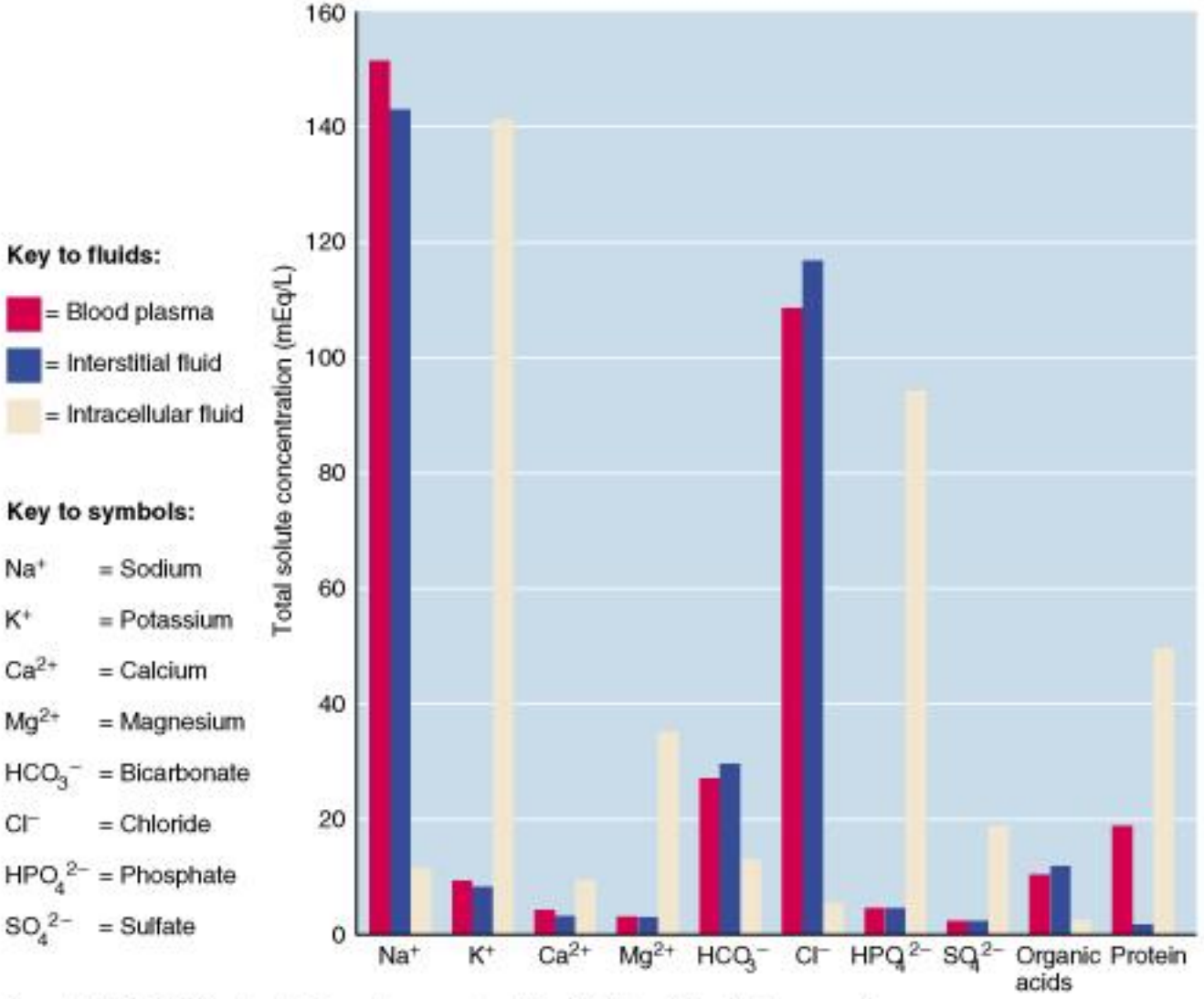


Other Interesting Graphic Relating to Fluid, pH and Electrolyte Balance









Questions

- What is an acid and does it raise or lower pH?
  - An acid is a solute that releases hydrogen ions
  - An acid is a proton donor
  - Acids lower pH
- What is a base and does it raise or lower pH?
  - A base removes hydrogen ions from a solution
  - Bases are proton acceptors
  - Bases raise the pH of a solution
- What is a salt?
  - A salt is a product of acid-base neutralization
  - It has a cation that is not H^+ and a anion that is not OH^-
- What is a buffer? Name 3 buffer systems in the body. Which is the most important?
  - A buffer is a compound that resists changes in pH
  - They stabilize pH by removing or replacing H+
  - The three buffers are
    - The protein buffer system
    - The phosphate buffer system
    - The carbonic acid-bicarbonate buffer system
- What is the first line of defense when pH balance is disturbed in the body?
  - The buffer system
- What is the second line of defense?
  - The respiratory and renal mechanism
- How does the respiratory mechanism raise pH in the body (3 things happen)?
  - H_2CO_3 (carbonic acid) dissociates
  - CO_2 is removed
  - H^+ is permanently tied up in H_2O
- How does the renal mechanism raise pH in the body?
  - By the secretion of H^+ into urine

For the Test (Test 3)

- Be able to write out and understand the formula for the carbonic acid-bicarbonate buffer system
  - $CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$
- What happens when the body's metabolic reactions produce extra H+
  - It associates with HCO_3^- to form H_2CO_3
- What happens if there is not enough H+ in body fluids
  - H_2CO_3 dissociates into H^+ and HCO_3^-
- What happens when H_2CO_3 travels by the alveoli?
  - H_2CO_3 dissociates into CO_2 and H_2O , CO_2 is removed during exhale and H^+ is permanently tied up in a water molecule