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Biochemistry

Acids and Bases 3

❖ Biological buffers

- Buffers in our bodies:
  - Dihydrogen phosphate-Monohydrogen phosphate system ($H_2PO_4^- \leftrightarrows HPO_4^{-2} + H^+$) → Intracellular
  - ATP, glucose-6-phosphate, bisphsphoglycerate → Intracellular mainly RBCs
  - Proteins (such as hemoglobin) → Intracellular and Extracellular
  - Carbonic acid-bicarbonate system ($H_2CO_3 \leftrightarrows HCO_3^- + H^+$) → The **major buffer in the blood**

❖ Bicarbonate buffer

- CO_2 is converted into carbonic acid in the RBCs inside the lungs which occurs rapidly (within minutes)

$$CO_2 + H_20 \rightleftharpoons H_2CO_3 \rightleftharpoons H^+ + HCO_3^-$$

- Carbonic acid dissociates instantaneously forming protons and bicarbonate
- Bicarbonate can be excreted via the kidney which is relatively slow (hours to days)

- The normal blood pH is **7.4 (7.35 – 7.45)**
- The pKa = **6.1** → its buffering range is 5.1 – 7.1
- The normal physiological pH is out of the buffering range of the bicarbonate buffer but it is also important because:
  - This buffer has a relatively **high concentration** in the ECF and blood
  - It is an **open system** where its components are under the **physiological control** (such as CO_2 by the lungs, bicarbonate by the kidneys)

❖ Acidosis & Alkalosis

- Changes in the pH of the blood out of the normal range causes pathologic conditions:
  - **Acidosis:** More acidic (pH decreases) → **blood pH < 7.35**
  - **Alkalosis:** More alkaline/basic (pH increases) → **blood pH > 7.45**

- They can be either metabolic or respiratory:
  - **Metabolic:** Caused by the changes in the concentration of acids and bases by metabolism
    - ✓ **Metabolic acidosis:** Production of Ketone bodies during starvation and diabetes mellitus patients also the administration of acids such as aspirin is large amounts, loss of bicarbonate
    - ✓ **Metabolic alkalosis:** High administration/ingestion of salts (mainly **Mg** alkaline salts), high loss of H^+ such as in vomiting
  - **Respiratory:** Caused by changes in the concentration of CO_2 in the blood
    - ✓ **Respiratory acidosis:** Increase in the concentration of CO_2 in the blood → Obstructive pulmonary diseases such as asthma, emphysema, COAD, Choking and bronchopneumonia
    - ✓ **Respiratory alkalosis:** Decrease the concentration of CO_2 → Hyperventilation, Anxiety hysterical over-breathing and raised intracranial pressure

❖ Compensation

- It is the process in which the body tries to **bring pH to the normal ranges**
  - If the **problem is metabolic**, the **compensation must be respiratory** (by hypo or hyperventilation)
  - If the **problem is respiratory**, the **compensation must be metabolic** (by changing bicarbonate)

- Compensation can be
  - **Complete** bringing pH **to the normal** pH range and limits (7.35 – 7.45)
  - **Partial** pH still **outside the normal** limits

Past papers

1. **A patient when an enteropathy (internal disease) produces large amounts of ammonia (NH_3) from bacterial overgrowth in the intestine. the ammonia was absorbed through the intestine into the portal vein, and entered the circulation. which of the following is a likely consequence of his ammonia absorption:**

   A. Increase expiration of CO_2
   B. Hypoventilation
   C. Conversion of ammonia to ammonium ion in the blood
   D. Decreased blood pH

2. **An individual wears a face mask for a long hours without removing it at all the condition that is expected to happen:**

   A. Metabolic acidosis
   B. Metabolic alkalosis
   C. Respiratory acidosis
   D. Respiratory alkalosis
   E. Nothing

3. **During a short distance run, the muscles produce a large amount of lactic acid from their glucose stores. Hyperventilation can be used for in this situation because:**

   A. Adds H^+ lowering the pH of the blood
   B. Increase the composition of bicarbonates
   C. Remove H+ raising the pH of the blood
   D. Reduce the capacity of hemoglobin buffer system
   E. Decreases the production of carbonic acid

4. **We have a drug that has [HA] ionizable acid with pKa of 4.5, that enters the cell via the membrane, what is the best pH that enhances the entry of the drug?**

   A. 1
   B. 3.9
   C. 9
   D. 4.8

سؤال 4 تابع للشيت السابق

5. **A patient with panic attacks and hyperventilation is in a respiratory alkalosis. The excess hydroxide ions were able to overcome by which one of the following buffers, which has the greatest buffering capacity in and near to normal blood pH**

   A. Dihydrogen phosphate (pKa = 6.8)
   B. Ammonium ion (pKa = 9.25)
   C. Acetoacetic acid (pKa = 3.62)
   D. Ascetic acid (pKa = 4.76)

6. Which one of the following works as a buffer?

A. KOH
B. NaOH
C. HCl
D. H_2SO_4
E. None of the above

7. The most effective buffer system in the body at physiological pH:

A. Bicarbonate buffer
B. Phosphate buffer
C. Protein buffer
D. All of the above

8. If a person suffered from acidosis caused, perhaps, by drinking acid:

A. The respiratory system would hypoventilate, keeping more CO_2 in the plasma
B. The lungs would hyperventilate, keeping CO_2 levels high in plasma
C. The kidneys would remove HCO_3^- from blood plasma and excrete it into the urine
D. The lungs would hyperventilate, decreasing CO_2 in the plasma, and the kidneys would save HCO_3^- and excrete it into blood plasma
E. The kidneys would remove CO_2 and excrete it into blood plasma rather than into urine

9. According to this reaction ($CO_2 + H_2O \leftrightarrow H_2CO_3 \leftrightarrow H^+ + HCO_3^-$)
If you dissolve some sodium bicarbonate in water and then add hydrochloric acid, one of the following should be seen (All the components of the reaction are water soluble, but carbon dioxide is a gas)

A. Carbon dioxide bubbling out
B. Carbon dioxide dissolving
C. Nothing, Carbon dioxide is an invisible gas
D. The solution should turn blue
E. The solution should turn red