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# Respiration Module

1st Year MBBS(SKL)

## Sample Preparation of Buffer Solution

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## Motto, Vision, Dream


- To impart evidence based research oriented medical education
- To provide best possible patient care
- To inculcate the values of mutual respect and ethical practice of medicine

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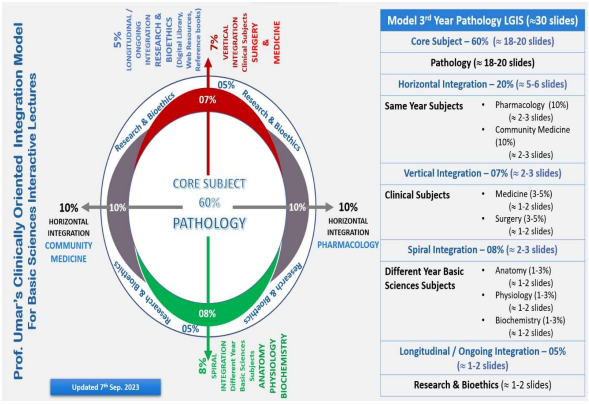
## Professor Umar Model of Integrated Lecture

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## Skill Lab Assessment

**Question 1:**

Which of the following is a characteristic finding in a patient with an anion gap metabolic acidosis?

A) Decreased bicarbonate level
B) Elevated PaCO2
C) Decreased anion gap
D) Elevated serum lactate
E) Respiratory alkalosis

**Question 2:**

A patient with chronic kidney disease presents with a blood pH of 7.30 and an HCO3- of 18 mEq/L. Which type of acid-base disorder is most likely present?

A) Respiratory acidosis
B) Metabolic acidosis
C) Metabolic alkalosis
D) Respiratory alkalosis
E) Compensated respiratory acidosis

**Question 3:**

What is the primary respiratory compensatory mechanism in response to metabolic alkalosis?

A) Decreased ventilation
B) Increased ventilation
C) Increased tidal volume
D) Decreased bicarbonate excretion
E) Increased respiratory rate

**Question 4:**

Which of the following would likely lead to respiratory acidosis?

A) Hyperventilation
B) Asthma exacerbation
C) Excessive sweating
D) Administration of bicarbonate
E) Metabolic alkalosis

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## Skill Lab Assessment

**Question 5:**

In a case of metabolic acidosis with a normal anion gap, which of the following is a likely cause?

A) Lactic acidosis
B) Diarrhea
C) Diabetic ketoacidosis
D) Renal failure
E) Salicylate toxicity

**Question:6**

Which of the following buffer systems is the most important extracellular buffer in human blood?

A. Histidine buffer
B. Protein buffer
C. Phosphate buffer
D. Ammonia buffer
E. Bicarbonate buffer

**Question 7:**

The buffering capacity of a solution is highest when:

A. pH equals the pKa of the buffer
B. Concentration of the acid is low
C. pH is much higher than pKa
D. Only strong acids are present
E. pH is much lower than pKa

**Question 8:**

Which of the following pairs acts as a buffer in the bicarbonate system?

A. $HCl/Cl^-$
B. $H_2PO_4^-/HPO_4^{2-}$
C. $NH_3/NH_4^+$
D. $CH_3COOH/CH_3COO^-$
E. $H_2CO_3/HCO_3^-$

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## Skill Lab Assessment

**Question 09:**

In the phosphate buffer system, the conjugate base is:

A. $H_2PO_4^-$
B. $PO_4^{3-}$
C. HCl
D. $H_2CO_3$
E. $HPO_4^{2-}$

**Question 10:**

The Henderson-Hasselbalch equation is used to calculate:

A. pH of a buffer solution
B. Osmolarity of plasma
C. Ionic strength
D. Rate of diffusion
E. Protein concentration

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## Key

1. B
2. D
3. A
4. B
5. B
6. E
7. A
8. E
9. E
10. A

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## Learning Objectives

At the end of the Skill Lab, students will be able to learn and explain:

1. The Normal Anatomy of the Body Buffer systems.
2. Physiology of the Acid Base Balance.
3. The Concept of Buffer and Buffer Solutions, with types
4. Sample Preparation of a Phosphate Buffer Solution
5. Skill lab Assessment.
6. The Use of Digital Library.

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Core Concept

## Buffer Solutions

**Definition:**

A buffer solution is a mixture of a weak acid and its conjugate base or a weak base and its conjugate acid.

The buffer resists changes in the pH value of the whole solution when a small amount of a different acid or alkali is introduced into the solution either through addition or via any chemical reaction within the solution.

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Core Concept

## Buffer Solutions

**Properties:**

**1.** Its pH doesn't change even when kept for a long time.

2. Buffer solutions are used to help maintain a stable pH value of another solution that is mixed with the buffer.

For example, blood contains natural buffers to maintain a stable pH of between 7.35 and 7.45 so that our enzymes work correctly, as enzyme activity varies with pH.

**Alternate names for Buffer:**

pH buffer/ Hydrogen ion buffer/ Buffer solution.

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Core Concept

## Types Of Buffer

1. **Acidic Buffer:**

A solution with weak acid and its salts containing strong bases is called an acidic buffer solution. E.g.,

A solution with $CH_3COOH$, which is weak acid and $CH_3COONa$, which is its salt is an acidic buffer solution.

2. **Alkaline Buffer:**

A solution with a weak base and its salt-containing strong acids is called a basic buffer solution. E.g.,

A solution with $NH_4OH$ as a weak base and $NH_4CL$, which is its salt, is an alkaline buffer solution.

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Core Concept

## Principle

**Mechanism of Buffering Action:**

In solution, the salt is completely ionized, and the weak acid is partly ionized.

**$CH_3COONa \rightleftharpoons Na^+ + CH_3COO^-$**

**$CH_3COOH \rightleftharpoons H^+ + CH_3COO^-$**

**Addition of Acid and Base**

1. On addition of acid, the released protons of acid will be removed by the acetate ions to form an acetic acid molecule.

**$H^+ + CH_3COO^-$ (from added acid) $\rightleftharpoons CH_3COOH$ (from buffer solution)**

2. On addition of the base, the hydroxide released by the base will be removed by the hydrogen ions to form water.

**$HO^- + H^+$ (from added base) $\rightleftharpoons H_2O$ (from buffer solution)**

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Core Concept

## The Dissociation/Ionization Constant

### Acid Ionization Constant

- **Acid Ionization Constant** ($K_a$): the equilibrium constant for the ionization reaction of an acid with water
  - $HA + H_2O \rightleftharpoons A^- + H_3O^+$

$$K_a = \frac{[H^+][A^-]}{[HA]}$$

- Large $K_a$ = Strong acid
- Small $K_a$ = Weak acid

### Base Ionization Constant

- **Base Ionization Constant** ($K_b$): the equilibrium constant for the ionization reaction of a base with water
  - $B + H_2O \rightleftharpoons OH^- + BH^+$

$$K_b = \frac{[BH^+][OH^-]}{[B]}$$

- Large $K_b$ = Strong base
- Small $K_b$ = Weak base

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Core Concept

## Preparation of a Buffer Solution

1. If the dissociation constant of the acid (pKa) and of the base (pKb) is known, a buffer solution can be prepared by controlling the salt-acid or the salt-base ratio.
2. These solutions are prepared by:

mixing the weak bases with their corresponding conjugate acids **OR**

mixing weak acids with their corresponding conjugate bases.

**For Example, A Phosphate Buffer; also an Intracellular Body Buffer:**

1. Phosphoric acid has multiple dissociation constants.
2. Phosphate buffers can be prepared near any of the three pHs, which are at 2.15, 6.86, and 12.32.
3. Most commonly prepared using monosodium phosphate and its conjugate base, disodium phosphate.

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Core Concept

## Overview

1. Select recipe from database
2. Recalculate recipe quantities according to the required buffer volume
3. Weigh compounds into the vessel
4. Dissolve the compounds in a suitable solvent (typically water)
5. Check and adjust the pH value by using a pH meter
6. Top up the solution to the required volume
7. Transfer to a storage bottle and label
8. Document results

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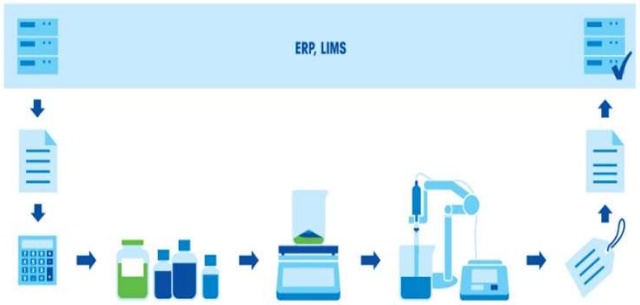
Core Concept

## Overview

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Core Concept

## Procedure

**Preparation of a Phosphate Buffer:**

**Materials:**

1. Monosodium phosphate
2. Disodium phosphate
3. Water
4. Phosphoric acid to make the pH more acidic or sodium hydroxide to make the pH more alkaline
5. pH meter
6. Glassware
7. Hot plate with stirring bar

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Core Concept

## Procedure contd.

**Preparation of a Phosphate Buffer at pH 7:**

1. Decide on the concentration of the buffer. If you make up a concentrated buffer solution, you can dilute it as needed.
2. Decide on the pH for your buffer. This pH should be within one pH unit from the pKa of the acid/conjugate base. So, you can prepare a buffer at pH 2 or pH 7.
3. Use the **Henderson-Hasselbach Equation** to calculate how much acid and base you need.

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Core Concept

## Procedure contd.

**Preparation of a Phosphate Buffer:**

**Calculation for 1 liter of buffer**

1. Select the pKa value that is closest to the pH of your buffer.
   We want the pH of buffer to be 7.00, use the pKa 6.962

   **pH = pKa + log ([Base]/[Acid])**

   **Ratio of [Base]/[Acid] = 1.096**
2. The molarity of the buffer is the sum of the molarities of the acid and conjugate base or the sum of [Acid] + [Base]. (Take 1 for easy calculation)

For a 1 M buffer:

**[Acid] + [Base] = 1**

**[Base] = 1 - [Acid]**

Substitute this into the ratio and solve:

**[Base] = 0.523 moles/L.**

**Now solve for [Acid]:**

**[Base] = 1 - [Acid],**

**So, [Acid] = 0.477 moles/L.**

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Core Concept

## Procedure contd.

**Preparation of a Phosphate Buffer:**

4. Prepare the solution:

- Mix 0.477 moles of monosodium phosphate and 0.523 moles of disodium phosphate in a little less than a liter of water.

5. Check the pH using a pH meter and adjust the pH as necessary using phosphoric acid or sodium hydroxide.
4. Once you have reached the desired pH, add water to bring the total volume of phosphoric acid buffer to 1 L.
5. If you prepared this buffer as a stock solution, you can dilute it to make up buffers at other concentrations, such as 0.5 M or 0.1 M.

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Core Concept

## Result

- 1 Liter, Standard Molarity,1M Phosphate Buffer at pH=7, made using Handersen-Hasselbach Equation.

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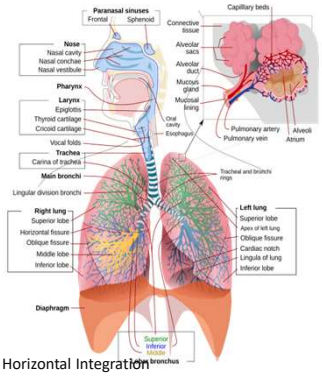
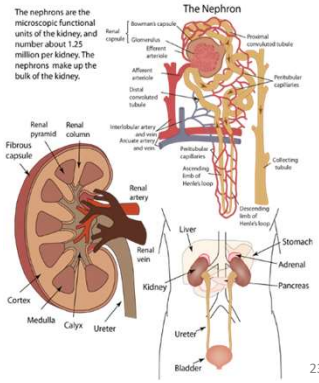
Horizontal Integration

## Anatomy of the Body pH Regulatory Systems

**Respiratory System**




**Renal System**




Horizontal Integration

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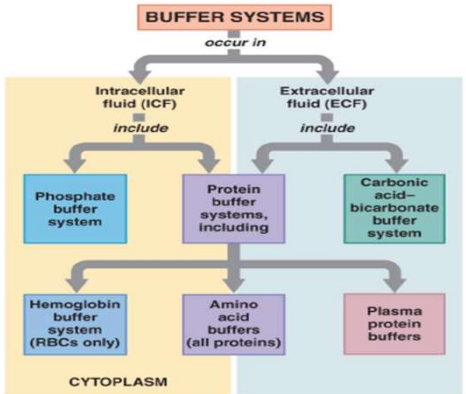
Horizontal Integration

## Physiology of Body Buffer System

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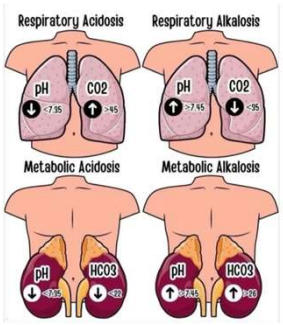
Vertical Integration

## Acid Base Disorders

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Spiral Integration — Family Medicine

## Management of Acid Base Disorders

Family Medicine plays important role in following manner:

- Diagnosis
- Education
- Dietary Guidance
- Monitoring
- Refer to Specialists

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Spiral Integration — Artificial Intelligence

## Role of AI in Management

Artificial Intelligence plays role in following aspects:

- Personalized Nutrition
- Diagnostic Tools
- Food Recommendations
- Drug Development

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Spiral Integration — Research Article

## Metabolic Acidosis

**MacKenzie Burger; Derek J. Schaller.**
Bookshelf
https://www.ncbi.nlm.nih.gov/

**Objectives:**

- Outline the causes of metabolic acidosis.
- Describe the presentation of a patient with metabolic acidosis.
- Summarize the treatment options for metabolic acidosis.
- Explain the importance of enhancing coordination amongst the interprofessional team to enhance the delivery of care to patients with metabolic acidosis.

Introduction:

Acid-base disorders, including metabolic acidosis, are disturbances in the homeostasis of plasma acidity. Any process that increases the serum hydrogen ion concentration is a distinct acidosis. The term acidemia is used to define the total acid-base status of the serum pH. For example, a patient can have multiple acidoses contributing to a net acidemia. Its origin classifies acidosis as either a respiratory acidosis which involves changes in carbon dioxide, or metabolic acidosis which is influenced by bicarbonate ($HCO_3$).

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Spiral Integration Bioethics

## Ethical Consideration

- Informed Consent
- Health care must allocate sources fairly, transparently and equitably
- Maintaining patient's confidentiality
- Research ethics

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## How to use HEC Digital Library

Steps to Access HEC Digital Library

1. Go to the website of HEC National Digital Library http://www.digitallibrary.edu.pk
2. On Home Page, click on the INSTITUTES.
3. A page will appear showing the universities from Public and Private Sector and other Institutes which have access to HEC National Digital Library (HNDL).
4. Select your desired Institute.
5. A page will appear showing the resources of the institution
6. Journals and Researches will appear
7. You can find a Journal by clicking on JOURNALS AND DATABASE and enter a keyword to search for your desired journal.

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## Learning Resources

- https://www.mt.com/us/en/home/applications/Laboratory_weighing/buffer-preparation.html#:~:text=Buffer%20preparation%20is%20a%20common,is%20mixed%20with%20the%20buffer.
- https://www.thoughtco.com/make-a-phosphate-buffer-solution-603665
- Google scholar
- Google images

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