Lab 5: pH Measurement and Solution Preparation

BIOL-8

Name: ______________________ **Date:** ______________________

Name: [ ] **Date:** [ ]

Objectives

By the end of this lab, you will be able to:

- **Define pH** and explain the pH scale
- **Measure pH accurately** using pH paper and digital pH meters
- **Explain the importance of pH** in biological systems
- **Describe how buffers work** to maintain stable pH
- **Prepare percent (%) solutions** and explain concentration calculations
- **Perform serial dilutions** and understand dilution factors

Introduction

The pH of a solution indicates its acidity or alkalinity. The "p" in pH stands for "potenz" (German for power) and the "H" represents hydrogen ions. The pH scale measures the concentration of hydrogen ions (H^+) in a solution.

The pH Scale:

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    ACIDIC                      NEUTRAL                   BASIC
    ←──────────────────────────────┼──────────────────────────→
    0   1   2   3   4   5   6   7   8   9   10  11  12  13  14
    |   |   |   |   |   |   |   |   |   |   |   |   |   |   |
    ▼   ▼   ▼   ▼   ▼   ▼   ▼   ▼   ▼   ▼   ▼   ▼   ▼   ▼   ▼
Battery Lemon Vinegar  Coffee Milk  Pure Baking  Sea  Ammonia Drain
 Acid Juice  (2.4)     (5)  (6.5) Water Soda  Water (11.5) Cleaner
(0.5) (2)                          (7)  (8.3)  (8)          (14)
```

Key Concepts:

- Each pH unit represents a **10-fold difference** in H^+ concentration
- pH 7 is neutral (equal H^+ and OH^- ions)
- pH < 7 is acidic (more H^+ ions)
- pH > 7 is basic/alkaline (more OH^- ions)

pH in the Human Body:

Body Location	Normal pH Range	Consequence if Abnormal
Blood	7.35 – 7.45	Life-threatening if outside range
Stomach	1.5 – 3.5	Needed for protein digestion
Saliva	6.2 – 7.4	Protects teeth, begins digestion
Urine	4.5 – 8.0	Varies with diet and health
Skin	4.5 – 6.5	Protects against pathogens

Part 1: Measuring pH of Common Solutions

> ***Learning Goal:*** *Practice using pH paper and understand the pH of everyday substances.*

Materials

- pH paper (wide range and/or narrow range)
- pH color chart
- Test tubes or small cups
- Various solutions to test
- Gloves (recommended)

Procedure — Using pH Paper

1. Tear off a small strip of pH paper
2. Dip briefly into the solution (or place a drop on the paper)
3. **Immediately** compare the color to the pH scale chart
4. Record the pH value
5. Use a fresh strip for each solution

Predictions and Measurements

Before testing, predict the pH of each solution (acidic, neutral, or basic):

Solution	Prediction (A/N/B)	Reasoning
Distilled water		
Lemon juice		
Baking soda solution		
Vinegar		

Data Collection

pH Measurements of Common Solutions

#	Solution	Color Observed	pH Value	Acidic/Neutral/Basic
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

Ranking Exercise

Rank your tested solutions from most acidic (1) to most basic:

1. ________ (pH = ____) ← Most Acidic
2. ________ (pH = ____)
3. ________ (pH = ____)
4. ________ (pH = ____)

5. ____________ (pH = ______)
6. ____________ (pH = ______)
7. ____________ (pH = ______)
8. ____________ (pH = ______) ← Most Basic

Analysis

1. Which solution was most acidic? Most basic?

Most acidic: ____________ (pH = ______)
Most basic: ____________ (pH = ______)

2. If lemon juice has pH 2 and coffee has pH 5, how many times more acidic is lemon juice?

3. Why is blood pH tightly regulated? What can happen if blood becomes too acidic (acidosis) or too basic (alkalosis)?

Part 2: Buffers and pH Stability

> ***Learning Goal:*** *Understand how buffers resist changes in pH.*

Background

A **buffer** is a solution that resists changes in pH when small amounts of acid or base are added. Buffers contain a weak acid and its conjugate base (or vice versa).

Why Buffers Matter:

- Blood contains bicarbonate buffer (H_2CO_3/HCO_3^-) to maintain pH 7.35-7.45
- Cells have phosphate buffers to protect enzymes
- Many biological processes only work within narrow pH ranges

Materials

- Buffer solution (pH 7)
- Distilled water (control)
- Dilute HCl (acid)
- Dilute NaOH (base)
- pH paper or pH meter
- Droppers

Procedure

Part A: Adding Acid

1. Place 10 mL of buffer solution in one test tube
2. Place 10 mL of distilled water in another test tube
3. Measure and record the initial pH of each
4. Add 5 drops of dilute HCl to each tube
5. Stir gently and measure pH again
6. Repeat with 5 more drops (10 total)

Part B: Adding Base

1. Repeat the procedure with fresh solutions
2. Add dilute NaOH instead of HCl

Data Collection

Effect of Adding Acid (HCl)

#	Solution	Initial pH	pH After 5 drops HCl	pH After 10 drops HCl	Total pH Change
1					
2					

Effect of Adding Base (NaOH)

#	Solution	Initial pH	pH After 5 drops NaOH	pH After 10 drops NaOH	Total pH Change
1					
2					

Analysis

1. Compare the pH changes in the buffer vs. distilled water. Which changed more?

2. In your own words, explain what a buffer does:

3. Why is it important that blood is buffered? What would happen if there were no buffering system?

4. People with severe vomiting may develop alkalosis (blood becomes too basic). Why would losing stomach acid affect blood pH?

Part 3: Preparing Percent Solutions

Learning Goal: *Learn to prepare solutions of specific concentrations.*

Background

Percent solutions express concentration as grams of solute per 100 mL of solution.

Types of Percent Solutions:

Type	Formula	Example
Weight/Volume (w/v)	(g solute / mL solution) × 100	5 g NaCl in 100 mL = 5% NaCl
Volume/Volume (v/v)	(mL solute / mL solution) × 100	10 mL ethanol in 100 mL = 10% ethanol

Formula for Making Percent (w/v) Solutions

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┌─────────────────────────────────────────────────────────────┐
│  Mass of solute (g) = (% desired × Volume needed) / 100     │
└─────────────────────────────────────────────────────────────┘

Example: Make 200 mL of 2% NaCl
Mass = (2 × 200) / 100 = 4 g NaCl

Dissolve 4 g NaCl in enough water to make 200 mL total volume
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Practice Problems

Calculate the mass of solute needed for each solution:

1. Prepare 100 mL of 5% NaCl (salt) solution:

Mass = (____ × ____) / 100 = ____ g NaCl

1. Prepare 250 mL of 10% glucose solution:

Mass = (____ × ____) / 100 = ____ g glucose

1. Prepare 50 mL of 3% starch solution:

Mass = (____ × ____) / 100 = ____ g starch

Hands-On: Prepare a Percent Solution

Your instructor will assign you a solution to prepare.

Solution Preparation Record

#	Assigned Solution	% Concentration	Volume to Make	Mass of Solute Needed	Mass Actually Used
1					

Procedure:

1. Calculate the mass of solute needed
2. Weigh the solute on a balance
3. Transfer to a graduated cylinder or volumetric flask
4. Add distilled water to approximately 2/3 of the final volume
5. Stir/swirl until dissolved
6. Add water to reach the exact final volume

Part 4: Serial Dilutions

Learning Goal: *Understand and perform serial dilutions.*

Background

A **serial dilution** is a series of stepwise dilutions where each step dilutes the previous solution by a fixed ratio. This technique is used to:

- Create a range of known concentrations
- Dilute samples to measurable levels
- Count bacteria or cells

Dilution Factor: The ratio of final volume to sample volume

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Dilution Factor = Final Volume / Sample Volume

Example: 1 mL sample + 9 mL water = 10 mL total
Dilution Factor = 10/1 = 10 (or "1:10 dilution")
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Serial Dilution Diagram

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Starting        Tube 1          Tube 2          Tube 3          Tube 4
Solution
   100%   →  1 mL + 9 mL  →  1 mL + 9 mL  →  1 mL + 9 mL  →  1 mL + 9 mL
             water            water            water            water

             10%              1%               0.1%             0.01%
          (1:10)           (1:100)          (1:1000)         (1:10000)
```

Practice Serial Dilution

Serial Dilution Data

#	Tube	Volume of Sample (mL)	Volume of Diluent (mL)	Dilution This Step	Cumulative Dilution	Final Concentration
1						
2						
3						
4						
5						

Analysis

1. If you perform three 1:10 serial dilutions starting with a 10% solution, what is the final concentration?

2. Why are serial dilutions more practical than trying to measure very small amounts directly?

3. In what real-world situations would serial dilutions be useful?

Conclusions

1. Explain why pH is important for the human body. Give at least two specific examples:

2. How do buffers help maintain homeostasis in living organisms?

3. A patient needs an IV solution that is 0.9% NaCl (normal saline). How many grams of NaCl would you need to prepare 1000 mL of this solution?

4. What new laboratory skills did you develop in this lab?

Quick Reference

pH Scale Summary

pH Range	Classification	Examples
0-6	Acidic	Stomach acid, vinegar, citrus

pH Range	Classification	Examples
7	Neutral	Pure water
8-14	Basic (Alkaline)	Baking soda, bleach, drain cleaner

Solution Preparation Formulas

Calculation	Formula
Mass for % solution	Mass (g) = (% × Volume in mL) / 100
Dilution factor	DF = Final Volume / Sample Volume
Final concentration	C_final = C_initial / Dilution Factor

Connection to Module 05: Understanding pH and solution preparation is essential for comprehending enzyme function, cellular metabolism, and homeostasis. Enzymes are highly sensitive to pH — each enzyme works optimally at a specific pH. Buffer systems in blood and cells maintain the stable pH needed for life. These foundational skills will be applied throughout your study of human biology.

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