# BIOL 102: Lab 2
# Solutions, Acids and Bases

### PRE-LAB ASSIGNMENT:

Students are expected to read pages 1 to 3 before coming to the lab to complete the experiments.

**Print this entire lab packet and bring it to the laboratory. You must submit the completed lab worksheet for credit. Please provide a FULL lab report for this experiment.**

**Objectives**:
After completing this laboratory assignment, students will be able to:

- Measure the pH of various liquids.
- Demonstrate that buffers stabilize the pH of a liquid.
- Measure the ability of commercial antacids to buffer the pH of a liquid.

**Acids:**
Acids are ionic compounds (compounds with a positive or negative charge) that break apart in water to form hydrogen ions ($H^+$). The strength of an acid is based on the concentration of $H^+$ in the solution. **The greater the concentration of $H^+$, the stronger the acid.**

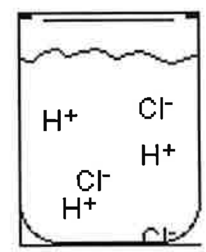

Figure 1: Hydrochloric acid (HCl) in water

Characteristics of Acids:

- Acids taste sour.
- Acids react strongly with metals (Zn + HCl).
- Strong acids are dangerous and can burn your skin.

Examples of Acids:

- Vinegar
- Stomach Acid (HCl)
- Citrus Fruits

**Bases:**
Bases are ionic compounds that break apart to form a negatively charged hydroxide ion ($OH^-$) in water. The strength of a base is determined by the concentration of hydroxide ions ($OH^-$). **The greater the concentration of $OH^-$, the stronger the base.** Solutions containing bases are often called ***alkaline***.

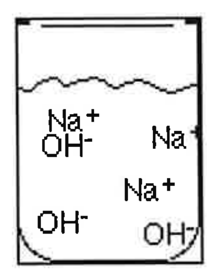

Figure 2: Sodium Hydroxide (NaOH) in water

Characteristics of Bases:

- Bases taste bitter.
- Bases feel slippery.
- Strong bases are very dangerous and can burn your skin.

Examples of Bases:

- Sodium hydroxide (lye)
- Ammonia

## pH Scale and Indicators

The strength of an acid or a base in a solution is measured on a pH scale. The pH scale is a measure of the hydrogen ion ($H^+$) concentration. It spans from 0 to 14 with the middle point (pH 7) being neutral (neither acidic nor basic). Any pH number **greater than 7** is considered a **base** and any **pH number less than 7** is considered an **acid**. 0 is the strongest acid and 14 is the strongest base. An **indicator** is a special type of compound that changes color as the pH of a solution changes, thus telling us the pH of the solution.

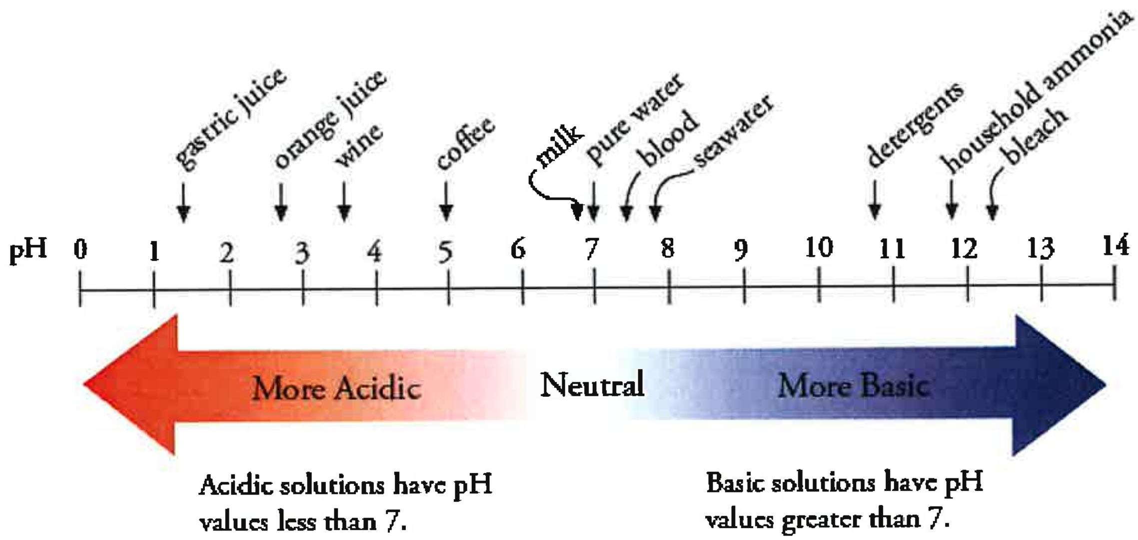


Figure 3: A pH scale indicating the pH of common substances.

## Measuring pH

A convenient way of measuring the pH of a solution is with pH paper. pH paper is treated with a chemical indicator that changes color depending on the concentration of $H^+$ in the solution that it has contacted. The color chart on the container of the pH paper is used to compare the color of the pH paper to determine the pH of the solution (see Table 1).

Table 1: Examples of pH indicators.

| ***Indicator*** | ***Range*** | ***Color Change*** |
|---|---|---|
| Methyl violet | 0.2 – 3.0 | Yellow to blue-violet |
| Bromphenol blue | 3.0 – 4.6 | Yellow to blue |
| Methyl red | 4.4 – 6.2 | Red to yellow |
| Litmus | 4.5 – 8.3 | Red to blue |
| Bromcresol purple | 5.2 – 6.8 | Yellow to purple |
| Phenol red | 6.8 – 8.0 | Yellow to red |
| Thymol blue | 8.0 – 9.6 | Yellow to blue |
| Phenolphthalein | 8.3 – 10.0 | Colorless to red |

## Buffers

Buffers are mixtures of two chemicals that stabilize the pH of a solution by resisting changes in the pH.

- If the pH is too low, one chemical will bind some of the hydrogen ions and raise the pH.
- If the pH is too high, the other chemical will donate some hydrogen ions to lower the pH.

**pH in the body**

The blood pH must be maintained very close to 7.4 which is slightly alkaline. A change of 0.2 pH units in either direction is considered dangerous and potentially fatal. Hydrogen ions are extremely reactive and affects many molecules which regulate physiological processes.

The body regulates pH in several ways including eliminating $CO_2$ by the lungs and eliminating other acids and bases by the kidneys. The most important way to minimize pH changes in the body is using buffers. All body fluids, inside or outside of the cells, have buffers which defend the body against pH changes. The most important buffer in extracellular fluids, including blood, is a mixture of carbon dioxide ($CO_2$) and bicarbonate anion ($HCO_3$). $CO_2$ acts as an acid because it forms carbonic acid when it is dissolved in water and donates hydrogen ions when they are needed. $HCO_3$ is a base, soaking up excess hydrogen ions. There are also other buffers in the blood, such as proteins and phosphates, but they are less important in maintaining the overall pH of the blood. Blood pH is established by a balance between bicarbonate and $CO_2$.

# LAB DATASHEET

**Exercise 1: Determining the pH of common substances**

1. Use pH paper to measure the pH of the following liquids.
2. Be as accurate as possible
3. Use a fresh piece of pH paper or pH dipstick for each test.
4. Record your data.

| | |
|---|---|
| Baking soda | 9.5 |
| 0.1M HCl | 1 pH |
| Vinegar | 2 |
| Tap water | 6 |
| Seltzer water | 5 |

**Exercise 2: Testing the buffering capacities of various solutions**

1. Obtain and label four test tubes according to the four solutions listed in Table 2.
2. Place 5 ml of each solution into its appropriately labeled tube.
3. Measure the pH of each of the solutions in the tubes and record these initial values in Table 2.
4. Add 5 drops of acid (0.1 M HCl) to the first tube. Cover the tube with parafilm and invert the tube gently to mix the contents.
5. Measure the pH of the acidified solution and record it in Table 2.
6. Repeat steps 4 and 5 for each of the remaining tubes. Record your results in Table 2.
7. Compare the initial pH and the pH after acid addition for each sample.

Table 2: Buffering Capacity Data

| Solutions | Initial pH | Final pH (after HCl) | Comparison of pHs |
|---|---|---|---|
| Water | 7 | 3 | -4 |
| 0.1 M NaCl | 5 | 2.5 | -2.5 |
| Skim milk | 6.5 | 6 | -0.5 |
| 0.1 M phosphate buffer | 7 | 7 | 0 |

**Analysis Questions:**

1. What is the biological importance of using a buffer?

2. Which of the solutions is the most effective buffer? Least effective?

**Exercise 3: Testing the effectiveness of commercial antacids and other products**
Commercial antacids such as *Alka Seltzer*, *Rolaids*, and *Tums* claim to "neutralize stomach acid" by absorbing excess hydrogen ions (produced as hydrochloric acid in the stomach).

To test the abilities of these products to absorb acids, do the following:

1. Using a pipet or 10 mL graduated cylinder, add 1 ml of the antacid solution to a test tube.
2. Add 1 drop of the indicator Bromcresol purple to the tube.
3. Cover the tube with parafilm and invert the tube to mix the contents.
4. Add one drop of 0.1 M hydrochloric acid (HCl) to the tube; mix after each drop.
    a. Continue this process until the solution turns yellow, indicating an acidic solution.
5. Record the number of drops of acid needed to generate the change of color.
    a. This number of drops is an index to the amount of acid (H+) that the solution neutralizes before the pH drops below the yellow end-point of Bromcresol purple.

Table 3: Effectiveness of Antacids Data

| **Antacids** | **Drops of Acid** |
|---|---|
| Alka – Seltzer | 16 |
| Rolaids | 3 |
| Tums | 1 |

**Analysis Questions:**

1. Which antacid neutralizes the acid best? Which neutralizes the acid least?

2. Examine the package of the products you tested. What are the active ingredients of each product?