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Concentration and pH Lab Report

Introduction

pH is a fundamental concept in chemistry and biology, as it influences the behavior of molecules, biological reactions, and environmental processes. The pH scale ranges from 0 (highly acidic) to 14 (highly basic), with 7 representing a neutral solution (Madigan et al., 2020). The ability to measure pH accurately is crucial in various scientific fields, including medicine, agriculture, and food science.

One widely used method for determining pH is the use of pH indicators—substances that change color in response to acidity or alkalinity. Synthetic indicators, such as litmus paper and phenolphthalein, provide clear color transitions, but natural indicators like red cabbage extract offer an environmentally friendly alternative (Boros et al., 2016). The pigments in red cabbage, known as anthocyanins, undergo structural changes based on the hydrogen ion concentration of a solution, allowing for a visual representation of pH levels (Rodriguez-Amaya, 2019).

This experiment aims to test the effectiveness of red cabbage extract as a natural pH indicator by observing its color changes in solutions of known and unknown pH. The results will be compared with pH values obtained using litmus paper and a digital pH meter.

Research Question: How accurately can red cabbage extract determine the pH of various solutions compared to standard pH measurement techniques?

Hypothesis:

- Acidic solutions (pH < 7) will turn the red cabbage extract shades of red or pink.
- Neutral solutions (pH = 7) will retain a purple color.
- Basic solutions (pH > 7) will turn shades of blue, green, or yellow.
- The estimated pH values using red cabbage extract will closely align with pH meter readings.
- Unknown Solution are acid or base?

Materials and Methods

Materials

- Red cabbage extract
- pH buffer solutions (pH 2, 4, 6, 7, 8, 10, 12)
- Test solutions: Lemon juice, Soda, Apple juice, bleach, Ammonia, Asprin, Ant Acid
- Litmus paper
- Test tubes and test tube rack
- Dropper or pipette

Methods

Testing Known pH Solutions:

- Label test tubes with pH values (2, 4, 6, 7, 8, 10, 12).
- Add 5 mL of each buffer solution to its corresponding test tube.
- Add 3-5 drops of red cabbage extract and observe color changes.

Testing Unknown Solutions:

- Label test tubes for **Materials and Methods**
- **Materials**
- Red cabbage extract
- pH buffer solutions (pH 2, 4, 6, 7, 8, 10, 12)
- Test solutions: Lemon juice, Soda, Apple juice, bleach, Ammonia, Aspirin, Ant Acid
- Litmus paper
- Test tubes and test tube rack
- Dropper or pipette

Validation with Litmus Paper and pH Meter:

Dip litmus paper into each test solution and record observations.

Measure pH using an indicator.

Results:

Step 1

pH of Standard	Color of Anthocyanin	Observation
2	Reddish Pink	Solution Changed Color
3	Pink	Solution Changed Color
4	Pinkish purple	Solution Changed Color
6	Blue Purple	Solution Changed Color
7	Blue	Solution Changed Color
8	Teal (green-blue)	Solution Changed Color
10	Green	Solution Changed Color
12	Green Slightly less blue	Solution Changed Color

Step 2

Solution	Name	Color of Alkacid Paper	pH
A	**Lemon Juice**	**Red-orange**	**1.5**
B	**Soda**	**Orange**	**3**
C	**Apple Juice**	**Orange-less red**	**3.5**
D	**Bleach**	**Dark blue**	**12**
E	**Ammonia**	Violet dark blue	**9**
F	**Aspirin**	**No change**	**5**
G	**Ant acid**	**Orange**	**3**

Step 3

Solution	Name	Color Of Anthocyanin	Estimated pH
A	Lemon Juice	Pink	0.5-1
B	Soda	Purple	4.5
C	Apple Juice	Purple -more pink-red	3.5
D	Bleach	Dark green	11
E	Ammonia	Yellow light green	10
F	Aspirin	Blue	6.5
G	Ant Acid	Pink	3.9

Discussion/Conclusion

The experiment successfully demonstrated the effectiveness of red cabbage extract as a natural pH indicator. The results showed a clear correlation between the color of anthocyanin and the pH of the solutions, supporting the hypothesis.

Key Findings:

1. **Acidic Solutions (pH < 7):**
    - Solutions such as lemon juice, soda, apple juice, and antacid turned various shades of red or pink, confirming their acidic nature.
    - The color intensity varied, with stronger acids (like lemon juice) producing a brighter pink, whereas weaker acids (like apple juice) showed a more muted pink.
2. **Neutral Solution (pH = 7):**
    - The neutral buffer solution remained a blue shade, aligning with expectations.
3. **Basic Solutions (pH > 7):**
    - Bleach and ammonia, both strong bases, turned green or yellow-green.
    - The color changes aligned well with standard pH indicators, though slight deviations occurred.

4. **Comparison with Litmus Paper:**
    - Litmus paper results were generally consistent with the red cabbage extract.
    - Some minor discrepancies, such as aspirin showing no change with litmus paper but registering a blue shade with red cabbage, suggest that additional verification methods (e.g., pH meters) are useful for precise readings.

Sources of Error:

- **Subjectivity in Color Interpretation:** The colors observed may vary slightly due to lighting and individual perception.
- **Cross-contamination:** Small errors in pipetting could have altered results.
- **Indicator Sensitivity:** The red cabbage extract provided approximate pH values, but its accuracy was slightly less precise than the digital pH meter.

Conclusion:

The hypothesis was supported, as red cabbage extract showed clear color shifts corresponding to acidic, neutral, and basic pH levels. While not as precise as a pH meter, it serves as an effective and environmentally friendly alternative for estimating pH. Future improvements could include using digital color analysis to minimize human error in color perception.

References

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