The pH of Salts

Background

Ionic compounds, commonly called salts, may cause a pH change when added to water. The way that salts change the pH of a solution can be predicted. In this activity, you will predict whether the pH of a solution will be acidic, basic, or neutral based on the formula of the salt being added.

How can the pH of the salt be predicted? Ionic compounds are composed of an anion and a cation. If the cation is an alkali or alkaline earth metal (with the exception of magnesium and beryllium) it will form a basic solution in water. How? These are the cations of strong bases. The hydroxides of these metals dissociate nearly completely when added to water, which produces the hydroxide ion and causes the pH to increase. Acidic solutions can also be predicted, as these salts will contain anions that form strong acids. Strong acids, like strong bases, will dissociate completely in water. When strong acids dissociate they produce the $H^+$ ions, which drops the pH of the solution. The strong acids are HCl, HBr, HI, HNO$_3$, H$_2$SO$_4$, and HClO$_4$; therefore, salts containing Cl$^-$, Br$^-$, I$^-$, NO$_3^-$, SO$_4^{2-}$, or ClO$_4^-$ ions will produce acidic solutions. If the salt contains both a strong base cation and a strong acid anion, the solution will be neutral.

When a salt is added to water, hydrolysis occurs. Hydrolysis is the decomposition of water. The strong ion acts as a spectator in the solution, where the weak ion bonds to form an acid or base. A net ionic equation can be written for this reaction. For example, calcium bicarbonate is a mineral commonly found in hard water. The calcium ion is a strong base cation and when calcium bicarbonate reacts with water, hydrolysis occurs and a basic solution is produced. The calcium ion acts as a spectator ion because it completely dissociates. The bicarbonate ion reacts with water to form carbonic acid, a weak acid that barely dissociates. The net ionic equation for the hydrolysis reaction that occurs is as follows:

$$\text{HCO}_3^- + \text{H}_2\text{O} \rightarrow \text{OH}^- + \text{H}_2\text{CO}_3$$

The presence of the hydroxide ion raises the pH of the solution significantly. The basic pH will turn red litmus paper blue and produce cool colors (green, blue, violet) in the presence of universal indicator solution.

Pre-Lab Questions

1. List the six strong acids:

2. Would nickel (II) hydroxide be considered a strong base? Why or why not?
3. Will lithium acetate produce an acidic or basic solution? Prove your answer by providing an equation for the reaction.

4. Predict the pH (acidic, basic, or neutral) of each salt by examining the formula for the compound.

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<th>Formula</th>
<th>pH</th>
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Objective
The purpose of this activity is to observe the change in pH of an aqueous solution when a salt is added and to explain this change.

Materials
- Six different ionic compounds
- Distilled water
- Six test tubes
- Test tube rack
- Masking tape
- Stirring rod
- Scoopula
- Litmus paper (red and blue)
- Universal indicator solution in a dropper bottle
- pH meter or pH probe

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- When you complete the lab, clean up all materials according to your teacher’s instructions.
- When working with acids, if any solution gets on your skin, you should immediately alert the teacher and thoroughly flush your skin with water.
- When working with acids and bases, if any solution gets on your skin immediately rinse the area with water.
Procedure
1. Six different salts are listed on the board. Use this information to fill in the first two columns on your data table.
2. Use the masking tape to label the test tubes with the formulas of the six salts being tested.
3. Fill each test tube ¾ full of distilled water.
4. Add 3 drops of universal indicator solution to each test tube.
5. Place a very small scoop of salt in each test tube according to their label.
6. Carefully mix the solution in the test tubes to dissolve the salts.
7. Write down color change observations in your data table.
8. Test each solution with red and blue litmus paper. In your data table, indicate if the solution tests acidic or basic.
9. Test each solution with the pH meter or probe. Indicate the measured pH of each solution in the data table. Make sure to rinse the probe with distilled water between each solution.
10. Clean your area according to your teacher’s instructions.

Data Table

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<tr>
<th>Salt Name</th>
<th>Salt Formula</th>
<th>Color Change</th>
<th>Litmus Test</th>
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Analysis
Briefly explain the pH change observed when each salt was dissolved in water. Determine the spectator ion for each salt. Write an equation for each hydrolysis reaction.

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<th>Salt Formula</th>
<th>Explanation</th>
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Post Lab Questions

1. Basic substances are commonly referred to as “alkaline”. Provide a brief explanation.

2. Why would potassium phosphate produce a basic solution while potassium nitrate produces a neutral solution? Explain.

3. Bleach, the household cleaner, contains the active ingredient sodium hypochlorite. Predict if bleach is acidic, basic, or neutral, and explain your answer.

4. (Optional) Write an equilibrium expression for each hydrolysis reaction.
5. (Optional) Look up the $K_a$ or $K_b$ for the acids or bases formed during each hydrolysis in the lab.

6. (Optional) Using the answers to questions 4 and 5, determine the pH of a 0.10M solution of each salt in which an acid or base formed.

**Conclusion**

Explain how the pH of a solution containing a salt can be predicted.