

AN INVESTIGATION INTO HYDROLYSIS
2019.20 AP Chemistry Lab/A.Collins **128 POINTS**

Hydrolysis reactions involve ions that manipulate water into becoming acidic or basic. If an ion causes the pH of a solution to drop, it is referred to as an acidic ion. If an ion causes the pH of a solution to increase it is referred to as a basic ion. Many ions do not affect the pH of solution and they are referred to as neutral ions. Lastly, some ions can be proton donors or proton acceptors. These ions display amphotericism and a quantitative analysis will reveal which process is dominant (whether it will end up being basic or acidic). In this lab, your group will predict the pH of 18 different solutions. To do this you will consider each of the dissociated ions and you will use math to determine the amphoteric ions.

THEORY:

An example of an basic ion (X^-): $X^- + H_2O \rightleftharpoons HX + OH^-$

An example of an acidic ion (Y^{2+}): This process takes place in multiple equilibrium steps.

1. *hydration step* $Y^{2+} + 4 H_2O \rightleftharpoons Y(H_2O)_4^{2+}$

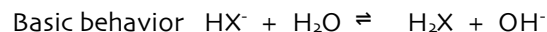
2. *hydrated ion interacts with an additional water molecule*



An example of an amphoteric ion: Assume that HX^- comes from the diprotic acid, H_2X



To determine which is stronger, acid or base, compare K_a to K_b



PURPOSE: 5 pts

What you are attempting to do and how you are going to do it.

PRE-LAB QUESTIONS: 26 points

1. Look at the term hydrolysis. Define the prefix hydro- and the suffix -lysis. What do they mean? What is the overall meaning of the term hydrolysis? 4 pts
2. Define the term *conjugate base*. Provide an example in a chemical equation. 3 pts
3. Define the term *conjugate acid*. Provide an example in a chemical equation. 3 pts
4. What would happen if I placed 17.9 mL of 4.00 molar acetic acid in a beaker containing 225.0 mL of distilled water? What would be the new, diluted molarity? What would be the pH of this solution at equilibrium? The K_a for acetic acid is 1.8×10^{-5} 8 points
5. If I placed 6.723 grams of sodium acetate in a beaker containing 275.0 mL of distilled water. What would the molarity of sodium acetate be? What would be the pH of this solution at equilibrium? 8 pts

ILLUSTRATED PROCEDURE: 10 pts

Place a drop or two of each of the following solutions into a porcelain well plate. Touch a small piece of universal indicator paper to the solutions. Immediately lay the paper on the white porcelain in order to gauge the color. After about 1 minute record the pH of each solution. If possible, use only whole integer numbers. Be careful to thoroughly clean the well plate using soap and tap water. After thoroughly rinsing the well plate with tap water, be sure to rinse off the tap water with distilled water. Do not touch the pH paper with your fingers, paper towels, or allow it to touch the lab bench. Use laboratory forceps!

Solutions to be tested:

- | | | |
|---|--------------------------------------|---|
| 1. Distilled H ₂ O (control) | 7. Ba(NO ₃) ₂ | 13. ZnSO ₄ |
| 2. FeCl ₃ | 8. KClO ₃ | 14. K ₂ HPO ₄ |
| 3. Na ₂ CO ₃ | 9. Na ₂ SO ₄ | 15. NaNO ₂ |
| 4. Mg(NO ₃) ₂ | 10. KCl | 16. Al ₂ (SO ₄) ₃ |
| 5. Zn(NO ₃) ₂ | 11. NaHCO ₃ | 17. Na ₂ S |
| 6. CuSO ₄ | 12. NaCH ₃ COO | 18. NaHSO ₃ |
| | | 19. NH ₄ Cl |

DATA SAFETY TABLE/PHYSICAL PROPERTIES: 10 pts

DATA TABLE: 20 pts

All balanced equations should be completed before you enter lab (do your homework!). You may modify them after seeing the lab results. However, you must get them signed (graded) before you leave the lab.

Solution	Color of pH Paper	pH	Hydrolysis? (Y or N)	Properly balanced equation for cations/anions
Example: Al(HCO ₃) ₃	Pinky/orange	3	Yes	Al ³⁺ + 6 H ₂ O ⇌ Al(H ₂ O) ₆ ³⁺ + H ₂ O ⇌ Al(H ₂ O) ₅ (OH) ²⁺ + H ₃ O ⁺ HCO ₃ ⁻ + H ₂ O ⇌ H ₂ CO ₃ + OH ⁻ (K _a for Al ³⁺ beats K _b for HCO ₃ ⁻)

ANALYSIS (in lieu of calculations): 10 points

Compare your data with that of other groups. You may want to repeat trials that do not coincide with the consensus of the majority (or the research you conducted prior to lab). Write a chemical equation for each solution that shows evidence of hydrolysis. Only the ones you said YES to above, silly! (include EQs in data table). Remember, there are very complex aqueous ions that form with metals. Look them up! Make sure you come up with the correct ratios!

CONCLUSION: 10 points

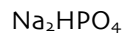
Summarize the regularities observed and compose a three-column list of those *ions* which do and do not hydrolyze. Columns should compare *acidic*, *neutral* and *basic* ions.

ERROR ANALYSIS: 10 points

Summarize, once again in a three-column format, to which column the ions belong (*acid*, *base* or *neutral*). You will need to consult an appropriate reference for your accepted values. Make sure you cite a source for this reference! If you are really competent, you can be the source! You will explain why your conclusion table does not match the theoretical table you just constructed.

POST LAB QUESTIONS 27 points

Predict what would occur when each of the following salts are dissolved in water. Use experimental results (from above) and reference tables as guidelines. Display a chemical equation representing chemical behavior. Also be sure to make a statement that identifies that this a hydrolysis reaction – *or not*. 15 points



5. Anhydrides are another class of compounds that react with water. Write an equation for the reaction of SO₂, an acid anhydride, with water. Is this reaction hydrolysis? 6 points

6. Underarm anti-perspirants use salts containing Al³⁺. Explain how Al³⁺ works to keep your underarms dry (focus on what you know about hydrolysis - not the internet). What rather negative side effect from using Al³⁺ results in the *aesthetic* degradation of your clothing? 6 points