

Salts in Water and Buffer Solutions Post-Lab
Chemistry for the Sciences II Spring 2009

Consult your text and lecture notes to answer the questions. **Written answers to these questions should be in your laboratory notebook, which will be due in my office (Hartline 204) by 5:00 pm on Friday, April 17th. You will receive your notebooks back on Monday the 20th, outside my office.** Please use the extra time to come in and ask questions!

1. Write a balanced equation for the protonation of ammonia, using water as a reactant.
 - a. What species is the conjugate acid of ammonia?
 - b. The K_b of ammonia is 1.8×10^{-5} . What is the K_a of its conjugate acid?

Now you have seen that the conjugate acid of a *weak* base can exhibit significant acid behavior. What about the conjugate base of a *weak* acid?

2. Write the balanced equation for the ionization of bicarbonate ion using water as a reactant.
 - a. The K_a of HCO_3^- is 5.6×10^{-11} . What is the K_b of its conjugate base?
3. Compare the K_a of NH_4^+ (calculated in question 1) with the K_b of HCO_3^- (calculated in question 2). Suppose a chemist prepares an aqueous solution of ammonium bicarbonate (NH_4HCO_3).
 - a. What species will be present in that solution?
 - b. For each species present in the solution, indicate whether it will behave as an acid, a base, or neither.
 - c. Since NH_4^+ is an acid and HCO_3^- is a base, will a solution of NH_4HCO_3 be neutral?? No, it depends on which species is better at what it does, i.e., is NH_4^+ a better acid than HCO_3^- is a base? Compare the K_a of NH_4^+ (calculated in question 1) with the K_b of HCO_3^- (calculated in question 2). Will $\text{NH}_4\text{HCO}_3(aq)$ be acidic, basic, or neutral? Explain your reasoning.

So, to predict whether an aqueous solution of a salt is acidic, basic, or neutral, one must consider the ions present, and how each ion behaves in solution.

4. Fill in the table below, as illustrated by the example in the first row.

Salt	Cation	Cation behavior	Anion	Anion behavior	Salt behavior
NaNO_2	Na^+	None	NO_2^-	Basic	Basic
CaCO_3					
NH_4NO_3					
K_3PO_4					
$\text{Al}(\text{NO}_3)_3$					
NH_4HCO_3					

5. How many moles of NH_4HCO_3 did you need to prepare 10 mL of a 0.10 M solution?
 - a. How many grams of NH_4HCO_3 did you need?
 - b. What pH did you measure for this solution?
 - c. Do your experimental results match your expectations from Question 3?
 - d. If not, did you complete Question 2 incorrectly, was there a problem with your experiment, or is there another reason why your answer didn't match your experimental finding?

6. In laboratory, you took 0.400 grams of aluminum nitrate nonahydrate and dissolved it in water in a 100-mL volumetric flask.
- What is the molarity of Al^{3+} ? Show your work!
 - What is the measured pH of the solution?
 - Consider the second to last entry in the above table (Question 4). Did your expectations from the table match your experimental pH? Why or why not?
 - Write out an equilibrium reaction for $\text{Al}(\text{H}_2\text{O})_6^{3+}$ in water.
 - Set-up an ICE table and calculate the K_a or K_b using your *experimentally measured pH* (an equilibrium calculation!). Compare with the literature value to that in your text/CRC. How well do they agree? Remember to cite the source you use.

The Preparation of a Buffer

7. Show your calculation for the ratio of the concentrations of HCO_3^- to CO_3^{2-} ions required to achieve buffering at $\text{pH} = 9.8$.
- What amounts of sodium carbonate and sodium bicarbonate did you use to make 250 mL of the buffer?
 - What is the pH of your solution?
 - What is the new pH after you added 1 drop of concentrated HCl to the solution?
 - How much did the pH change?
 - Measure the pH of a 250-mL sample of distilled water.
 - What is the new pH of the distilled water after you added 1 drop of concentrated HCl?
 - How much did the pH change?
 - Did the buffer solution seem to resist changes in pH when compared to the water? Explain.
8. Show your calculation for the ratio of the concentrations of acetic acid and acetate ion required to achieve buffering at $\text{pH} = 5.1$.
- What amounts of acetic acid and sodium acetate did you use to make 250 mL of the buffer? (Remember the rules!)
 - Describe in detail how you measured out the correct amounts of acetic acid and sodium acetate to construct this buffer solution.
 - What is the pH of your solution?
 - What is the new pH after you added 1 drop of concentrated HCl to the solution?
 - How much did the pH change?
 - How did the pH change you measured in 8e compare to the pH change measured for the distilled water in 7e-g? Is the bicarbonate/carbonate buffer better or worse at resisting pH change than the acetic acid/acetate buffer? Can you explain why one is better than the other at resisting pH changes?
9. What is meant by *buffer capacity*?
10. At what pH values are **acid** buffers MOST effective, assuming equal molarities of the acid and its conjugate base? Name an **acid** buffer system and the pH where it is most effective.
11. Consult the table of $\text{p}K_a$ values suggest acid/conjugate base system that would yield a pH of 6.0. Explain your selection.
12. Novocain, which is used by dentists as a local anesthetic, is a weak base with a $\text{p}K_b = 5.05$. Blood has a pH of 7.4. What is the ratio of concentrations of Novocain to its conjugate acid in the bloodstream?

13. A buffer solution is prepared by mixing 50.0 mL of 0.022 M $\text{C}_6\text{H}_5\text{COOH}(aq)$ (benzoic acid) and 20.0 mL of 0.032 M $\text{NaC}_6\text{H}_5\text{CO}_2(aq)$.
- What is the pH of the buffer solution?
 - What are the pH and the change in pH after the addition of 10.0 mL of 0.054 M HCl to the buffer solution?
 - What are the pH and the change in pH after the addition of 10.0 mL of 0.054 M HCl to a 50.0 mL solution of 0.022 M $\text{C}_6\text{H}_5\text{COOH}$ (not the buffer)?