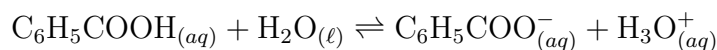


Chemistry 192

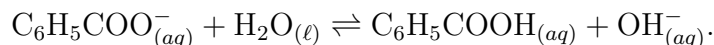
Problem Set 4

Spring, 2018

1. The ionization constant of benzoic acid in water associated with the reaction



is $K_a = 6.3 \times 10^{-5}$. Calculate the value of K_b associated with the reaction

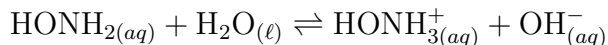


Answer: $K_b = 1.6 \times 10^{-10}$

2. Use the data and/or results from problem 1 to calculate the pH of a 0.100 M solution of sodium benzoate, $\text{NaC}_6\text{H}_5\text{COO}$.

Answer: pH=8.60

3. The ionization constant of hydroxylamine producing the hydroxylammonium ion via the reaction



is $K_b = 9.1 \times 10^{-9}$. Calculate the pH of a 0.0100 M solution of hydroxylammonium chloride.

Answer: pH=3.96

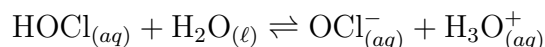
4. Using the ionization constant of acetic acid



calculate the mass of sodium acetate that must be added to 100. mL of water to produce a solution with pH=8.00.

Answer: 0.015 g

5. The ionization reaction of hypochlorous acid with water

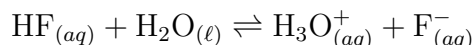


has a $\text{p}K_a = 7.54$. Consider a 0.100 M NaOCl (sodium hypochlorite) solution.

- (a) Do you expect the pH of the NaOCl solution to be less than or greater than 7.00? Explain your reasoning.
- (b) Calculate the pH of a 0.100 M NaOCl solution given sodium hypochlorite is completely ionized in water.

Answer: pH=10.27

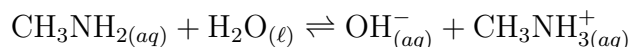
6. The ionization constant for hydrofluoric acid via the reaction



is $K_a = 6.6 \times 10^{-4}$. Calculate the concentration of fluoride ion in a 0.100 M hydrofluoric acid solution and an aqueous mixture 0.100 M aqueous HF and 0.0100 M HCl. Recall that HCl is completely ionized in water.

Answer $[\text{F}^-] = 4.4 \times 10^{-3} \text{ M}$

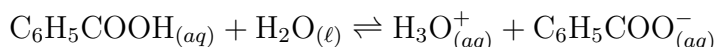
7. Aqueous methylamine is a weak base with the reaction



having ionization constant $K_b = 4.2 \times 10^{-4}$. A 0.0100 M solution of methylamine is mixed with sufficient sodium hydroxide to yield a solution having pH=9.30. Calculate the concentration of the methylammonium ions and methylamine in the solution.

Answer: $[\text{CH}_3\text{NH}_3^+] = 9.5 \times 10^{-3} \text{ M}$, $[\text{CH}_3\text{NH}_2] = 5.0 \times 10^{-4} \text{ M}$

8. The value of K_a for the dissociation of benzoic acid



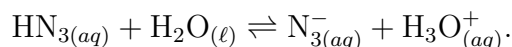
is 6.3×10^{-5} . Calculate the pH of a solution that is 0.0100 M in benzoic acid and 0.0100 M in sodium benzoate.

Answer: pH=4.20

9. For benzoic acid as in problem 8, calculate the pH of a solution that is 0.0100 M in benzoic acid and 0.0500 M in sodium benzoate.

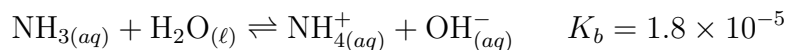
Answer: pH=4.87

10. Sodium azide (NaN_3) is a highly toxic and highly water soluble salt made from sodium hydroxide (NaOH , a strong base) and hydrazoic acid (HN_3 , a weak acid). Sodium azide solutions are completely ionized in water. It is found that a 0.100 M aqueous solution of sodium azide has a pH=8.80. Calculate the $\text{p}K_a$ of the reaction



Answer: $\text{p}K_a = 4.60$

11. For aqueous ammonia using the reaction



calculate the pH of a solution that is 0.0100 M in ammonia and 0.0500 M in ammonium chloride.

Answer: pH=8.56

12. Calculate the pH when 100. mL of the solution discussed in problem 8 is combined with 20.0 mL of 0.0100 M hydrochloric acid.

Answer: pH=4.02

13. Calculate the pH when 100. mL of the solution discussed in problem 11 is combined with 20.0 mL of 0.0100 M hydrochloric acid.

Answer: pH=8.44

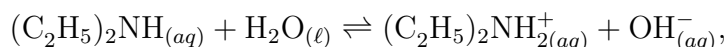
14. Calculate the pH when 100. mL of the solution discussed in problem 8 is combined with 20.0 mL of a 0.0100 M aqueous sodium hydroxide solution.

Answer: pH=4.37

15. From the dissociation constant of benzoic acid given in problem 8, calculate the number of grams of sodium benzoate that must be added to 100. mL of 0.0100 M benzoic acid to produce a solution buffered to pH = 4.00.

Answer: 0.91 g

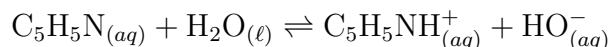
16. The weak base diethylamine reacts with water according to the reaction



and the equilibrium constant for the reaction is $K_b = 6.9 \times 10^{-4}$. A buffer solution is formed by mixing diethylamine and diethylammonium chloride having concentrations $[(\text{C}_2\text{H}_5)_2\text{NH}] = 0.124$ M and $[(\text{C}_2\text{H}_5)_2\text{NH}_2^+] = 0.224$ M. Calculate the pH of the final solution when 0.400 L of the buffer are mixed with 0.1500 L of 0.0150 M NaOH (a strong base).

Answer: pH=10.61

17. Pyridine ($\text{C}_5\text{H}_5\text{N}$) reacts with water as a weak base according to the reaction



with associate base ionization constant $K_b = 1.5 \times 10^{-9}$. A buffer is made by combining aqueous pyridine and pyridinium chloride ($\text{C}_5\text{H}_5\text{NHCl}$) of concentrations $[\text{C}_5\text{H}_5\text{N}] = 0.200$ M and $[\text{C}_5\text{H}_5\text{NH}^+] = 0.300$ M. A 0.100 L sample of the buffer is then mixed with 0.0100 L of 0.235 M aqueous hydrochloric acid (HCl, a strong acid). Calculate the pH of the mixture of the buffer and hydrochloric acid.

Answer: pH=4.92

18. The base dissociation constant of phenylamine ($\text{C}_6\text{H}_5\text{NH}_2$) is $K_b = 5.0 \times 10^{-10}$. A solution is prepared that is 0.100 M in phenylamine and 0.200 M in phenylammonium cation ($\text{C}_6\text{H}_5\text{NH}_3^+$). A 0.100 L sample of the buffer is then mixed with 0.100 L of 0.0100 M sodium hydroxide (a strong base). Calculate a) the pH of the initial buffer solution, and 2) the pH of the buffer/sodium hydroxide mixture.
Answer: Buffer, pH=4.40, mixture pH=4.46.
19. A buffer of volume 0.400 L is 0.250 M in formic acid (HCOOH) and 0.350 M in the formate (HCOO^-) anion. The buffer is then combined with 0.100 L of 0.0250 M sodium hydroxide. Given the $\text{p}K_a$ of formic acid is 3.74, calculate the pH of the mixture of the buffer with the NaOH solution. Approximations work for this problem.
Answer: pH=3.90
20. Ethanolamine, $\text{HO}(\text{CH}_2)_2\text{NH}_2$ is a weak base in aqueous solutions, and its conjugate acid, $\text{HO}(\text{CH}_2)_2\text{NH}_3^+$ is called the ethanolammonium ion. The $\text{p}K_b$ of ethanolamine is 4.50. A buffer is formed by mixing 0.10 moles of $\text{HO}(\text{CH}_2)_2\text{NH}_2$ with 0.20 moles of $\text{HO}(\text{CH}_2)_2\text{NH}_3^+$ to make an aqueous solution having a final total volume of 0.500 L. Calculate a) the pH of the buffer, and b) the pH if the buffer is mixed with 0.100 L of 0.050 M hydrochloric acid (a strong acid). Approximations work for this problem.
Answer: a) Original buffer, pH=9.20; b) after mixing, pH=9.17
21. Ethyl amine ($\text{C}_2\text{H}_5\text{NH}_2$) is a weak base with $\text{p}K_b = 3.37$. A buffer is made by combining 0.025 moles of ethyl amine and 0.050 moles of an ethyl ammonium salt ($\text{C}_2\text{H}_5\text{NH}_3^+$) with water so that the total volume is 0.25 L. The buffer is then combined with 0.020 L of 0.100 M hydrochloric acid (HCl). Calculate 1) the initial pH of the buffer, and 2) the pH of the buffer after the addition of the hydrochloric acid. **Answer:** pH 1= 10.33, pH2 = 10.28