Chapter 16: Acid Base Equilibrium

ACID IONIZATION EQUILIBRIUM

16.35 Acrylic acid, whose formula is HC\(_3\)H\(_3\)O\(_2\) or H\(_2\)C = CH-COOH, is used in the manufacture of plastics. A 0.10 M aqueous solution of acrylic acid has a pH of 2.63. What is the \(K_a\)-value for acrylic acid?
[Ans: \(K_a = 5.6 \times 10^{-5}\)]

16.36 Heavy metal azides, which are salts of hydrazoic acid, HN\(_3\), are used as explosive detonators. A solution of 0.20 M hydrazoic acid has a pH of 3.21. What is the \(K_a\)-value for hydrazoic acid?
[Ans: \(K_a = 1.9 \times 10^{-6}\)]

16.38 Formic acid, HCHO\(_2\), is used to make methyl formate and ethyl formate. What is the pH of a 0.10 M solution of formic acid? What is the degree (percent) ionization? \(K_a = 1.7 \times 10^{-4}\).
[Ans: 4.1%]

16.41 A solution of Acetic Acid, HC\(_2\)H\(_3\)O\(_2\), on a laboratory shelf was of undetermined concentration. If the pH of the solution was found to be 2.68, what was the concentration of the acetic acid solution?
[Ans: [HOAc] = .26M]

16.44 Chloroacetic Acid, HC\(_2\)H\(_2\)ClO\(_2\), has a greater acid strength than acetic acid, because the electronegative chlorine atom pulls electrons away from the O-H bond and thus weakens it. Calculate the hydronium ion concentration and the pH of a 1.0020 M solution* of chloroacetic acid. \(K_a = 1.3 \times 10^{-3}\).
[Ans: pH = 1.44] (The solutions manual bases its calculation on a 1.0020 M chloroacetic acid solution, but the text problem lists a 0.002 M concentration. Use the 1.0020 M for this problem and ‘x’ is negligible; i.e., no need to use quadratic equation).

16.47 Phthalic acid, H\(_2\)C\(_8\)H\(_4\)O\(_4\), is a diprotic acid used in the synthesis of phenolphthalein indicator. \(K_{a1}=1.2 \times 10^{-3}\), and \(K_{a2}=3.9 \times 10^{-6}\). (a) Calculate the hydronium-ion concentration of a 0.015 M solution. (b) What is the concentration of the C\(_8\)H\(_4\)O\(_4^{2-}\) ion in the solution? Note: Quadratic Equation is required on this problem.)
[Ans: (a) \([H_3O^+] = 3.7 \times 10^{-3}\) M; (b) \([C_8H_4O_4^{2-}] = K_{a2} = 3.9 \times 10^{-6}\) M]

BASE IONIZATION EQUILIBRIUM

16.49 Write the chemical equation for the base ionization of methylamine, CH\(_3\)NH\(_2\). Write the \(K_b\) expression for methylamine. (Extra) What is the pH of a 0.10 M solution of methylamine given \(K_b = 4.4 \times 10^{-4}\).
[Ans: pH = 11.82]

16.52 Trimethylamine, (CH\(_3\))\(_3\)N, is a gas with a fishy, ammonia-like odor. An aqueous solution that is 0.25 M trimethylamine has a pH of 11.63. What is the \(K_b\)-value for trimethylamine? [Ans: \(K_b = 7.3 \times 10^{-5}\)]

16.53 What is the concentration of hydroxide ion in a 0.060 M aqueous solution of methylamine, CH\(_3\)NH\(_2\)? What is the pH? (\(K_b = 4.4 \times 10^{-4}\))
ACID – BASE PROPERTIES OF SALT SOLUTIONS: HYDROLYSIS

Write the hydrolysis reactions for the following ions:

- a. \( \text{NO}_3^- \)
- b. \( \text{OCl}^- \)
- c. \( \text{NH}_4^+ \)
- d. \( \text{Br}^- \)
- e. \( \text{C}_2\text{H}_5\text{O}_2^- \)
- f. \( \text{CN}^- \)
- g. \( \text{(C}_6\text{H}_5\text{)}\text{NH}_3^+ \)

From the Hydrolysis reaction, determine whether the solutions are acid, basic or neutral.

Calculate the \( K_a' \)-value for hydrolysis of \( \text{NH}_4^+ \). \( K_b(\text{NH}_4\text{OH}) = 1.8 \times 10^{-5} \). [Ans: \( 5.6 \times 10^{-10} \)]

16.63  (a) Determine the \( K_a \)-value for \( \text{NO}_2^- \). \( K_a(\text{HNO}_2) = 4.5 \times 10^{-4} \). [Ans: \( 2.22 \times 10^{-11} \)]

(b) Determine the \( K_a \)-value for \( \text{C}_2\text{H}_5\text{NH}^+ \). \( K_a(\text{C}_2\text{H}_5\text{N}) = 1.4 \times 10^{-9} \). [Ans: \( 7.1 \times 10^{-6} \)]

16.65  What is the pH of a 0.025 M aqueous solution of sodium propionate, \( \text{NaC}_3\text{H}_5\text{O}_2 \)? What is the concentration of propionic acid in the solution? \( K_a(\text{HPro}) = 1.3 \times 10^{-5} \)  [Ans: pH = 8.64 ]

16.66  Calculate the \( \text{OH}^- \) concentration and pH of a 0.0020 M aqueous solution of sodium cyanide, \( \text{NaCN} \). Finally, obtain the hydronium ion concentration, pH and, \( \text{CN}^- \) concentrations. [Ans: \( [\text{OH}^-] = 1.92 \times 10^{-4} \text{M} \), \( [\text{H}_3\text{O}^+] = 5.2 \times 10^{-11} \text{M} \), pH = 10.28, \( [\text{CN}^-] = 0.0018 \text{ M} \)]. Note: The quadratic equation is needed in this problem.

16.67  Calculate the concentration of pyridine, \( \text{C}_5\text{H}_5\text{N} \), in solution that is 0.15 M pyridinium bromide, \( \text{C}_5\text{H}_5\text{NHBr} \). What is the pH of the solution? [Ans: \( [\text{PyN}] = 0.00103 \text{ M} \), pH = 2.99 ]

16.68  What is the pH of a 0.35 M solution of methylammonium chloride, \( \text{CH}_3\text{NH}_3\text{Cl} \)? What is the concentration of methylamine in the solution? [Ans: pH = 5.55 ]

COMMON-ION EFFECT

16.69  Calculate the degree of ionization of (a) 0.75 M HF (Hydrofluoric Acid) solution, and (b) the same solution that is also 0.12 M in HCl. [Ans: (a) 3.0%; (b) 0.57%]

16.70  Calculate the degree of ionization of (a) 0.22 M HCHO\textsubscript{2} (formic acid) solution and, (b) the same solution that is also 0.12 M HCl. [Ans: (a) 2.8% ; (b) 0.14%]

16.71  What is the pH of a solution that is 0.10 N KNO\textsubscript{2} and 0.15 M HNO\textsubscript{2} (Nitrous Acid)? [Ans: 3.17]

16.72  What is the pH of a solution that is 0.20 M KO\textsubscript{CN} and 0.10 M HO\textsubscript{CN} (cyanic acid)? [Ans: 3.76]

16.73  What is the pH of a solution that is 0.10 M CH\textsubscript{3}NH\textsubscript{2} (methylamine) and 0.15 M CH\textsubscript{3}NH\textsubscript{3}Cl (methylammoniumchloride)? [Ans: pH =10.47]

16.74  Ca. pH for 0.15 M \( \text{C}_2\text{H}_3\text{NH}_2(aq) + 0.10 \text{ M C}_2\text{H}_3\text{NH}_3\text{Br.} \)  [Ans: pH = 10.85]
BUFFER SOLUTIONS

16.75 A buffer is prepared by adding 45.0 ml of 0.15 M NaF to 35.0 ml of 0.10 M HF. What is the pH of the final solution? ($K_a(HF) = 6.8 \times 10^{-4}$) [pH after mixing = 3.45]

16.77 What is the pH of a buffer solution that is 0.10 M NH$_3$ and 0.10 M NH$_4^+$? What is the pH if 12 ml of 0.20 M HCl(aq) is added to 125 ml of buffer? (pH Buffer = 9.25; pH after adding acid = 9.10)

16.79 What is the pH of a buffer solution that is 0.15 M chloroacetic acid and 0.10 M sodium chloroacetate? ($K_a = 1.3 \times 10^{-3}$). (pH Buffer = 2.71)

16.81 What is the pH of a buffer solution that is 0.15 M Pyridine and 0.10 M Pyridinium bromide? What is the pH after adding 0.08 M HCl? ($K_b$ (pyridine) = $1.4 \times 10^{-9}$)
(pH Buffer = 5.3 & after adding 0.08 M HCl pH = 4.73)

TITRATION CURVES

Titration Problems will be combined into a complete titration series calculation

a) For Strong Acid + Strong Base, and
b) For Weak Acid + Strong Base.