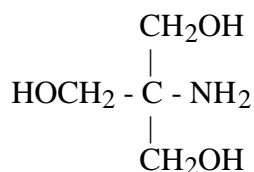


Biochemistry 311 Problem Set: pH and Buffer

1. Calculate the $[H^+]$ of a) blood plasma, pH 7.4, b) cow's milk, pH 6.6, c) gastric juice, pH 1.5, d) tomato juice, pH 4.3, and e) cola drink, pH 2.8.
2. The pK_a values of acetic acid and trichloroacetic acid are 4.7 and 0.7, respectively. Which is the stronger acid and what are the corresponding dissociation constants?
3. What is the $[OH^-]$ of 0.1 M HCl solution?
4. The K_b for ammonia (NH_3) is 1.8×10^{-5} mole liter⁻¹. What is its K_a value?
5. Calculate the pH of a 0.001 M solution of dichloroacetic acid, K_a 5.0×10^{-2} .
6. The pH of 0.1 M HCl is 1.0, of 0.1 M acetic acid is 2.8. What volume of 0.1 N NaOH would be required to titrate 10 mL aliquots of each acid solution to their respective end points?
7. Which is stronger, a 1/20 M H_2SO_4 solution or a 1/10 M acetic acid solution? Explain. (The first proton dissociates from sulfuric acid completely, the second pK_a is 1.9; the pK_a of acetic acid is 4.7.)
8. Make up 1 liter of 0.01 M sodium acetate buffer at pH 4.5. The pK_a of acetic acid is 4.7. Calculate the grams of anhydrous sodium acetate (m.w. 82) and number of milliliters of glacial acetic acid (m.w. 60; specific density 1.049 g/mL) required. By the way, what is the molarity of glacial acetic acid?
9. If 10 mL of an acid at 0.09 M gave rise to a solution of pH 5.9 when mixed with 20 mL of 0.15 M potassium salt of itself, what is the pK_a of this acid?
10. To 100 mL of 0.2 M formic acid ($HCOOH$), pK_a 3.8, is added 10 mmoles of NaOH. What will be the final pH?
11. The dissociation constant for lactic acid ($CH_3CHOHCOOH$) is 1.4×10^{-4} . How much lactic acid must be added to 2 g of NaOH to make 500 mL of lactate buffer at pH 4.0?
12. Calculate the amounts of acetic acid and sodium hydroxide required to prepare 1 liter of 0.05 M acetate buffer at pH 3.8. K_a of acetic acid is 1.8×10^{-5} .
13. If one mixed 100 mL of 0.1 M sodium acetate with 100 mL of 0.1 M acetic acid, the pH of the solution obtained is 4.7. What would be the new pH if 80 mL of 0.1 N NaOH were added to this solution?

14. (a). A very common buffering substance used in the biochemistry labs is Tris, which stands for tri(hydroxymethyl)aminomethane (see structure below). It is usually supplied in the conjugate base form called Trisma Base. How would you prepare a 0.5 L of a 0.1 M Tris buffer at pH 7.6 using solid Trisma Base (m.w. 121) and 1 N HCl? Tris-HCl has a pK_a of 8.3.



- (b). Instead of starting with solid Trisma Base, a student found stock solutions of 1 M Trisma Base and 1 M Tris Hydrochloride (the conjugate acid form) in the lab and proceeded to mix 50 mL of 1 M Tris.HCl with 10 mL of 1 M Trisma Base, fine adjusted the pH to 7.6, and then diluted 50 mL of the mixture with H₂O to 500 mL. Did the student make the buffer correctly? Explain.
15. You need to make a 0.1 M phosphate buffer at pH 7.2. Given 1 M stock solutions of H₃PO₄, NaH₂PO₄, Na₂HPO₄, and Na₃PO₄, how might you go about doing this? How about a 0.25 M buffer of pH 6.8? pK_{a1} of phosphoric acid is 2.1; pK_{a2} , 6.8; and pK_{a3} , 12.3.
16. The two most important inorganic buffer systems in the body are the phosphoric acid and carbonic acid systems. At the pH of blood (7.4), what is the ratio of the following? The pK_a values for the phosphoric acid system are 2.1, 6.8, 12.3, and for the carbonic acid system, 6.1 and 10.2. Which conjugate acid-base pair is responsible for the buffering at physiological pH?

$$\frac{[\text{PO}_4^{3-}]}{[\text{HPO}_4^{2-}]}, \frac{[\text{HPO}_4^{2-}]}{[\text{H}_2\text{PO}_4^-]}, \frac{[\text{H}_2\text{PO}_4^-]}{[\text{H}_3\text{PO}_4]}, \frac{[\text{CO}_3^{2-}]}{[\text{HCO}_3^-]}, \frac{[\text{HCO}_3^-]}{[\text{H}_2\text{CO}_3]}$$

17. Calculate how you would prepare 1 liter of a 0.1 M histidine buffer, pH 7.0, starting from histidine dihydrochloride (C₃H₁₁N₃O₂Cl₂, m.w. 228), 0.5 N NaOH, and water. The pK_a values of histidine are 1.8 (-COOH), 9.3 (-NH₃⁺), and 6.0 (-imidazole).
18. The pK_a values for arginine are 2.2 (-COOH), 9.1 (-NH₃⁺), and 12.5 (-guanidino). What are the possible ionic forms of this amino acid? Calculate the relative amounts of each ionic form at pH 10.8.
19. (a). Write the structural formula of Lys-His-Tyr.
 (b). What is the approximate pI of this tripeptide?
 (c). In what pH regions would this peptide act as a buffer?
20. An oligopeptide has the acronym CHEMISTRY based on the single-letter amino acid code. Write out its structural formula and determine its approximate pI. At physiological pH, what is the overall charge structure of this peptide?