

Practice Problems: Acid-Base, Buffers

- In the titration of 80.0 mL of 0.150 M ethylamine, $C_2H_5NH_2$, with 0.100 M HCl, find the pH at each of the following points in the titration.
 - Initially, before any HCl has been added.
 - At the halfway point in the titration.
 - At the endpoint.
 - At 1/4 completion (the "one fourth of the way point")
 - At 3/4 completion
 - 10.0 mL of HCl beyond the endpoint.
- What volume of HCl is needed to reach each of the above points? (1 a-f above)
- What would be an appropriate indicator for the titration in #1?
- What volume of 0.120 M NaOH must be added to 100 mL of 0.100 M $NaHC_2O_4$ to reach a pH of 4.70?
- Describe the effect on the pH that results by adding
 - $NaNO_2$ to HNO_2
 - $NaNO_3$ to HNO_3 .Why are the effects not the same?
- A buffer solution is prepared by dissolving 1.51 g of NH_3 and 3.85 g of $(NH_4)_2SO_4$ in 0.500 L of solution.
 - What is the pH of this solution?
 - If 0.88 g of NaOH is added, what is the pH?
- A buffer solution is prepared by dissolving 1.50 g each of benzoic acid, $HC_7H_5O_2$, and sodium benzoate, $NaC_7H_5O_2$, in 150.0 mL of solution.
 - What is the pH of this buffer solution?
 - Which buffer component must be added, and in what quantity, to change the buffer pH to 4.00?
 - What quantity of 2.0 M NaOH or 2.0 M HCl must be added to the original buffer to change the pH to 4.00?
- In lab, you have the following chemicals available to you:
1.00 M NaOH, 1.00 M HCl, 1.00 M H_3PO_4 , NaH_2PO_4 (s), Na_2HPO_4 (s), and Na_3PO_4 (s).
Describe 3 different ways of making 200 mL of a buffer of pH = 12.10 in which the least concentrated buffer component is 0.10 M. Use only the above chemicals, plus distilled water.

ethylamine $C_2H_5NH_2$	$K_b = 4.7 \times 10^{-4}$	NH_3	$K_b = 1.8 \times 10^{-5}$
$H_2C_2O_4$	$K_{a1} = 5.9 \times 10^{-2}$	H_3PO_4	$K_{a1} = 6.9 \times 10^{-3}$
$HC_2O_4^-$	$K_{a2} = 5.1 \times 10^{-5}$	$H_2PO_4^-$	$K_{a2} = 6.2 \times 10^{-8}$
benzoic acid $HC_7H_5O_2$	$K_a = 6.3 \times 10^{-5}$	HPO_4^{2-}	$K_{a3} = 4.8 \times 10^{-13}$

Some numerical answers:

1a: 11.91, 1b: 10.67, 1c: 5.95, 1d: 11.15, 1e: 10.19, 1f: 2.32, 2a: 0 mL, 2b: 60. mL, 2c: 120 mL, 2d: 30. mL, 2e: 90. mL, 2f: 130 mL, 3: methyl red, 4: 60. mL, 6a: 9.44, 6b: 9.74, 7a: 4.13, 7b: add 0.52 g benzoic acid, 7c: add 0.82 mL HCl, 8: Mix 3.3 g sodium phosphate and 4.7 g sodium hydrogen phosphate, dilute to 200. mL. OR Mix 7.5 g sodium hydrogen phosphate with 20 mL 1.00 M NaOH and dilute to 200 mL with di water. OR Mix 8.7 g sodium phosphate with 33 mL 1.00 M HCl and dilute to a total volume of 200 mL with di water.