Practice Problems: Acid-Base, Buffers

1. 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.
   a. Initially, before any HCl has been added.
   b. At the halfway point in the titration.
   c. At the endpoint.
   d. At 1/4 completion (the "one fourth of the way point")
   e. At 3/4 completion
   f. 10.0 mL of HCl beyond the endpoint.

2. What volume of HCl is needed to reach each of the above points? (1 a-f above)

3. What would be an appropriate indicator for the titration in #1?

4 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?

5. Describe the effect on the pH that results by adding
   a. $NaNO_2$ to HNO_2
   b. $NaNO_3$ to HNO_3.
   Why are the effects not the same?

6. 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.
   a. What is the pH of this solution?
   b. If 0.88 g of NaOH is added, what is the pH?

7. 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.
   a. What is the pH of this buffer solution?
   b. Which buffer component must be added, and in what quantity, to change the buffer pH to 4.00?
   c. 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?

8. 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.

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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.