More Acid/Base, Buffer Problems

1. Phenol, C_6H_5OH, is a weak organic acid that has been used as a disinfectant. Suppose 0.515 g of the compound is dissolved in 100. mL of water. The resulting solution is titrated with 0.123 M NaOH. What are the concentrations of all of the following species at the equivalence point: Na^+, H_3O^+, OH^-, $C_6H_5O^-$, and C_6H_5OH? What is the pH of the solution?

2. What volume of 0.150 M KOH is needed to add to 100. mL of 0.230 M H_3PO_4 to get a buffer with a pH of 2.50?

3. 50.0 mL of 0.200 M HClO is titrated with 0.220 M NaOH. Find the pH of the solution at each of the following points in the titration:
   a. Initially, before any base is added.
   b. At the equivalence point.
   c. At the halfway point.
   d. At the 1/4 way point.
   e. At the 2/3 way point.
   f. After 18.0 mL of NaOH has been added.
   g. 10.0 mL past the endpoint.

4. What would be a good choice of indicator for this titration?

5. What mass of Na_3PO_4 would you add to 80.0 mL of 0.200 M HCl to obtain a buffer with a pH of 7.75?

6. In a buffer containing HNO_2 and NO_2^-, the pH is 3.00.
   a. Which buffer component is in the greater concentration?
   b. If the concentration if HNO_2 is 0.400 M in 200. mL of the above solution, how many grams of which buffer component must be added to reach a pH of 3.50?
   c. To the original solution in part b (200. mL of buffer containing 0.400 M HNO_2 with a pH of 3.00), what volume of 1.50 M HCl or 1.50 M NaOH must be added to reach a pH of 3.50?
   d. How many grams of which buffer component must be added to the original solution (in part b) to get a pH of 2.75?
   e. What volume of 2.00 M HCl or 2.00 M NaOH must be added to the original solution (in part b) to get a pH of 2.75?

7. You need to make 500. mL of a buffer of pH 9.00 in which the most concentrated buffer component is 0.500 M. Describe three different ways of making the buffer. The chemicals available are:

1.5 M $HC_2H_3O_2$	$NaC_2H_3O_2$ (s)
1.5 M HClO	NaClO (s)
H_3BO_3 (s)	NaH_2BO_3 (s)
2.5 M HCl	deionized water
2.5 M NaOH	

OVER for K_a and K_b values

C_6H_5OH	$K_a = 1.1 \times 10^{-10}$	HNO_2	$K_a = 4.5 \times 10^{-4}$
H_3PO_4	$K_{a1} = 6.9 \times 10^{-3}$	$HClO$	$K_a = 3.5 \times 10^{-8}$
$H_2PO_4^-$	$K_{a2} = 6.2 \times 10^{-8}$	$HC_2H_3O_2$	$K_a = 1.8 \times 10^{-5}$
HPO_4^{2-}	$K_{a3} = 4.8 \times 10^{-13}$	H_3BO_3	$K_a = 5.9 \times 10^{-10}$

Some numerical answers:

1. $[Na^+] = 0.379$ M, $[H_3O^+] = 5.5 \times 10^{-12}$ M, $[OH^-] = 1.8 \times 10^{-3}$ M, $[C_6H_5O^-] = 0.0361$ M, $[C_6H_5OH] = 1.8 \times 10^{-3}$ M, pH = 11.26
2. Add 105 mL KOH
3a: 4.08, 3b: 10.24, 3c:7.46, 3d: 6.98, 3e: 7.76, 3f: 7.27, 3g: 12.32
4. Alizarin yellow
5. 2.1 g Na_3PO_4
6a: HNO_2, 6b: 5.4 g $NaNO_2$, 6c: 21.4 mL NaOH, 6d: 2.9 g HNO_2, 6e: 6.3 mL HCl
7. Mix 15.5 g H_3BO_3 and 12.4 g NaH_2BO_3 and add water until total volume is 500. mL
OR Mix 24.6 g H_3BO_3 and 59 mL NaOH, dilute to 500. mL with di water
OR Mix 33.3 g NaH_2BO_3 and 100 mL HCl., and dilue to 500 mL with di water.