Acid/Base and Solubility Equilibria Practice Problems

Acid/Base

1. Trimethylamine, $(CH_3)_3N$, has a $K_b$ value of $6.3x10^{-5}$. What is the conjugate acid of trimethylamine, and what is its $K_a$ value? Write the acid ionization equation of this conjugate acid.

2. Precisely 50.0 mL of NaOH solution of unknown concentration is titrated with a standardized solution of HCl with a concentration of 0.258 M. If it takes 28 mL of HCl solution to reach the endpoint, what is the concentration of the NaOH solution?

3. Sodium hydroxide is often titrated against the primary standard potassium hydrogen phthalate, KHP (molar mass = 204.22 g/mol), in order to determine the precise concentration of a sample of NaOH. They react in a 1:1 stoichiometric ratio. If you begin by dissolving 0.625 g of KHP into an Erlenmeyer flask, and it takes 8.75 mL of NaOH to reach the endpoint, what is the standardized concentration, in molarity, of the sodium hydroxide?

4. A buffer is typically made directly from a weak acid and it's conjugate base. However, the irreversible neutralization reaction of a weak acid and strong base can also create the conjugate base needed for the buffer solution, as seen below with the reaction of acetic acid with hydroxide:

   $$CH_3COOH + OH^- \rightarrow CH_3COO^- + H_2O$$

   As long as the base is added in such amount as there is appreciable acid left over, this then creates a situation where we have an appreciable amount of the weak acid and it's conjugate base, forming a buffer. With that in mind, calculate the pH of a buffer made from mixing 3.5 L of 0.55 M acetic acid ($K_a=1.8x10^{-5}$) with 1.5 L of 0.50 M NaOH.

5. 50.0 mL of 0.450 M hypochlorous acid, HClO, $K_a=2.9x10^{-8}$, is titrated with 0.225 M NaOH. Calculate the pH of the resulting solution _____
   a. initially (before any NaOH is added)
   b. after the addition of 35.0 mL of NaOH
   c. after the addition of 50.0 mL of NaOH
   d. after the addition of 100.0 mL of NaOH
   e. after the addition of 115.0 mL of NaOH

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Solubility Equilibria

6. One liter of a saturated solution of $MgF_2$ (MW = 62.3 g/mol) contains 0.0726 g of dissolved $MgF_2$
    a. What is the solubility in mol/L?
    b. What is the $K_{sp}$ of $MgF_2$?

7. $K_{sp}$ for $Mg(OH)_2$ is $1.2 \times 10^{-11}$. A solution has a concentration of 0.00200 M $Mg^{2+}$ and 0.00030 M $OH^-$. Will a precipitate of $Mg(OH)_2$ form? Explain.

8. The $K_{sp}$ of CuBr is $6.27 \times 10^{-9}$.
    a. Calculate the solubility, in mg/L, of CuBr (molar mass=143.45 g/mol) in pure water
    b. Calculate the solubility, in mg/L, of CuBr (molar mass=143.45 g/mol) in 0.20 M NaBr.

9. The $K_{sp}$ for $Mg(OH)_2$ is $1.2 \times 10^{-11}$
    a. Calculate the solubility, in mg/L of $Mg(OH)_2$ (molar mass = 58.32 g/mol) in pure water.
    b. Calculate the solubility, in mg/L of $Mg(OH)_2$ (molar mass = 58.32 g/mol) in a solution with a pH of 11.0

10. A solution contains 0.00025 mol of KBr and 0.25 mol of KCl per liter. AgNO3 is gradually added to this solution. Which forms first, solid AgBr or solid AgCl?
    $K_{sp}$ AgBr = $5.0 \times 10^{-13}$
    $K_{sp}$ AgCl = $1.6 \times 10^{-10}$