1999 Exam #3 – Chem 36 Exam Questions *with Answers*

1. For acetic acid, $K_a = 1.76 \times 10^{-5}$ at 25 °C.

   a. Calculate the pH in a solution prepared by dissolving 0.070 mol of acetic acid and 0.035 mol of sodium acetate in water and adjusting the volume to 500.0 mL.

      pH = 4.45

   b. Suppose 0.015 mol of HCl is added to the buffer from part a. Calculate the pH of the solution that results (assume that the total solution volume remains 500.0 mL).

      pH = 4.13

   c. Suppose 0.015 mol of HCl were added to 500.0 mL of pure water instead of the buffer solution in part a. Calculate the pH of the solution that results (again, assume that the total solution volume remains 500.0 mL).

      pH = 1.52

2. The base ionization constant of ethylamine ($C_2H_5NH_2$) in aqueous solution is $K_b = 6.41 \times 10^{-4}$. For the titration of 50.00 mL of a 0.1000 M solution of ethylamine with 0.1000 M HNO_3:

   a. How many mL of HNO_3 must be added to reach the equivalence point of the titration?

      50.00 mL

   b. At the equivalence point of the titration, is the solution acidic, basic or neutral (pH= 7.00)? Explain.

      Acidic (all of ethylamine has been converted to its *conjugate acid*)

   c. What is the pH of the titration mixture after adding 51.00 mL of the HNO_3 to the ethylamine solution?

      pH = 3.00

3. Soluble barium compounds are poisonous, but barium sulfate ($BaSO_4$) is routinely ingested as a suspended solid (yum!) in a "barium cocktail" to improve the contrast in x-ray images.

   a. Calculate the concentration (mol/L) of dissolved barium in a saturated aqueous solution of barium sulfate ($K_{sp} = 1.1 \times 10^{-10}$).

      1.0 x 10^{-5} mol Ba^{2+}/L

   b. The sulfate ion is also the conjugate base of HSO_4^- ($K_a = 1.2 \times 10^{-2}$), and it can undergo the following reaction in water:

      $$SO_4^{-2} + H_2O \leftrightarrows HSO_4^- + OH^-$$

      Based on this equilibrium, does the very acidic environment of the stomach increase or decrease the solubility of barium sulfate? Explain.

      H^+ will react with OH^-, shifting SO_4^{2-} hydrolysis to the right. This decreases the amount of SO_4^{2-} in solution, shifting the $BaSO_4$ solubility equilibrium to the right, increasing the solubility of $BaSO_4$.

4. Complete and balance the following equation for a reaction in basic solution:

   $$MnO_4^- + H_2S \rightarrow Mn^{2+} + SO_4^{2-}$$

   (NOTE: You must show all your work to get full credit!)

   $$8MnO_4^- + 5H_2S + 2H_2O \rightarrow 8Mn^{2+} + 5SO_4^{2-} + 14OH^-$$

5. A galvanic cell is constructed in which a $Pt|Fe^{2+}, Fe^{3+}$ half-cell is connected to a $Cd^{2+}|Cd$ half-cell.

   a. Write the balanced chemical equation for the half-reaction occuring at the anode.

      $$Cd\ (s) \rightarrow Cd^{2+}\ (aq) + 2e^-$$

   b. Write the balanced chemical equation for the half-reaction occuring at the cathode.

      $$Fe^{3+}\ (aq) + e^- \rightarrow Fe^{2+}\ (aq)$$

c. Calculate the cell voltage, assuming that all reactants and products are in their standard states.

E^{o}_{cell} = +1.173 volts

d. Calculate the equilibrium constant for the overall reaction.

K = 4. x 10^{39}

6. An $I_2(s)|I^-$ (1.00M) half-cell is connected to an $H_3O^+|H_2$ (1 atm) half-cell in which the concentration of the hydronium ion is unknown. The measured cell voltage is 0.632 volts and the $I_2|I^-$ half-cell is the cathode. What is the pH in the $H_3O^+|H_2$ half-cell?

7. An electrolytic cell consists of a pair of metallic electrodes in a solution buffered to a pH = 5.00 and contains Pb^{2+} at a concentration of 1.00 M.

   a. Calculate the mass of Pb that is formed as a result of passing a current of 5.00 amperes through the solution for 5.0 hours.

   b. If the solution were buffered to a pH = 0.00, how much Pb would be produced from the above electrolysis? Explain.