Problem 1 (20 Points)
Given that the following multiple equilibria take place in water:

$PbF_{2\,(s)} \rightleftharpoons Pb^{2+}_{(aq)} + 2F^-_{(aq)}$ $\quad K_{sp} = 3.6 \times 10^{-8}$

$F^-_{(aq)} + H_2O_{(l)} \rightleftharpoons HF_{(aq)} + OH^-_{(aq)}$ $\quad K_b = 1.5 \times 10^{-11}$

$2\,H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$ $\quad K_w = 1.00 \times 10^{-14}$

Using the systematic approach to solving multiple equilibria, write the mass balance, charge balance and equilibria based algebraic expressions you would use to solve for the solubility of PbF_2 in water. Also list the soluble chemical species (Unknowns) for which concentrations could be determined.

Mass Balance Equation:

Charge Balance Equation:

Equilibria Based Algebraic Equations:

<u>Unknowns</u>

Problem 2 (20 Points) Note: This is a two part problem.

a) (10 points) Find the pH of a solution prepared by dissolving **10.876 grams** of ammonia (**NH_3**, molecular weight=17.03) and **15.572 grams** of ammonium chloride (**$NH_4^+ \cdot Cl^-$**, molecular weight=53.49) in **2.00** Liter of water. The **pK_b** of ammonia (**NH_3**) is **4.756**.

pH=_____

b) (10 points) If **50.00 mL** of **1.00 M HCl** had been added to the solution in part (a), what would be the new pH of the solution?

pH=_____

Problem 3 (20 Points) Note: this is a two part problem

(a) What is the pH of a solution prepared by dissolving **6.6035 grams** of sodium acetate ($NaOOCCH_3$ - **mw=82.03 g/mole**) in **2.000** Liters of water. The pK_a of acetic acid is **4.757**. **(b)** What is the **fraction** of association (α) of sodium acetate in this solution?

(a) pH=_____ (b) α = _____

Problem 4 (15 Points)

The **bismuth oxycarbonate $(BiO)_2CO_3$ (mw = 509.97 g/mole)** in a veterinary drug tablet was analyzed by dissolving a **0.2005** gram sample in dilute HNO_3 and precipitating the Bi^{3+} as BiOCl **(mw = 260.43 g/mole)** by addition of Cl^-. After drying at 100 degrees C, the BiOCl precipitate was found to weigh **0.0512** grams. Calculate the weight percent **$(BiO)_2CO_3$** in the original sample.

weight % **$(BiO)_2CO_3$** = _____ %

Problem 5 (5 Points)

What would be the approximate pH of a 1.00 L pure water solution to which 1 $x10^{-9}$ moles of NaOH was added?

pH ≈ _____

Problem 6 (20 Points)

A **100.0 mg** sample of an ore that contained chromium was dissolved by acid and the **chromium (Cr)** was oxidized to chromate ion, $\mathbf{CrO_4^{2-}}$ (molecular weight = 115.9921 g/mole). **5.00 mL of 0.2000 M $\mathbf{Ag^+}$** (as soluble $AgNO_3$) was added to the solution to precipitate the CrO_4^{2-} as $\mathbf{(Ag_2CrO_4)_{(s)}}$. The Ag_2CrO_4 precipitate (Ag_2CrO_4 has a molecular weight = 331.7285 g/mole) was removed by filtration and discarded. The **excess** Ag^+ in the remaining solution required **14.50 mL of 0.0450 M KSCN** for titration. (a) How many **moles of Cr** were in the original ore sample? (b) What was the **weight % of Cr (atomic weight of Cr = 51.9961 g/mole)** in the ore sample?

(a) _____ **moles Cr** (b) **Wt. % Cr** = _____ %