CHEM 301
Assignment #4 (Optional)

Provide solutions to the following questions in a neat and well organized manner.
Clearly state assumptions and reference sources for any constants used.
(odd numbered questions only) December 7th

1. The Maximum Acceptable Concentration of mercury in water is 0.001 ppm. Is the MAC likely to be exceeded by the dissolution of a) **HgS**(s) (K_{sp} = 1 x 10^{-56}) and b) **HgO**(s) (solubility reported as 5.3 mg per 100 mL). Are either of your answers affected by the pH or pe of the water sample? Explain.

2. An effluent waste stream contains 330 mg L^{-1} organic matter (suspended and dissolved) and 27 mg L^{-1} ammonium ion (as **N**). Write chemical equations for the complete oxidation of {$\mathbf{CH_2O}$} and $\mathbf{NH_4^+}$ and calculate the total BOD load of this effluent in mg/L $\mathbf{O_2}$.

3. A sewage treatment plant is designed to process 3.0 x 10^{12} L of sewage daily.
a) What capacity (m^3) is required for the primary settling lagoon if the residence time is to be 6 hours?
b) If the influent water has a BOD of 850 ppm, what volume of oxygen at 15°C is required per day to reduce the BOD by 90%.

4. Calculate the mass of lime ($\mathbf{Ca(OH)_2}$(s)), required to chemically treat 27,000 m^3 of waste water containing 6.1 mg L^{-1} of phosphorous. Assume the following reaction goes to completion when a two fold molar excess of $\mathbf{Ca(OH)_2}$ is used.

$$5\ \mathbf{Ca(OH)_2} + 3\ \mathbf{HPO_4^{2-}} \rightarrow \mathbf{Ca_5(PO_4)_3OH} + 6\ \mathbf{OH^-} + 3\ \mathbf{H_2O}$$

5. A sewage sample contains 8.8 ppm of dissolved phosphorous in the form of ortho phosphate. It is brought to pH of 9.0 and [$\mathbf{Ca^{2+}}$] = 4.7 mM by the addition of $\mathbf{Ca(OH)_2}$. What is the concentration of dissolved phosphorous (as ppm **P**) when it's in equilibrium with precipitated calcium phosphate (K_{sp} $\mathbf{Ca_3(PO_4)_2}$ = 1 x 10^{-24})?

6. Iron can occur as a carbonate mineral $\mathbf{FeCO_3}$, which has a $K_{sp} = 3.1 \times 10^{-11}$. Calculate the concentration of of iron (ppm) in groundwater in equilibrium $\mathbf{FeCO_3}$ and $\mathbf{CaCO_3}$. The concentration of $\mathbf{Ca^{2+}}(aq) = 120$ ppm. Hint: use the K_{sp} of $\mathbf{CaCO_3}$ of 6.0×10^{-9} to estimate the $[\mathbf{CO_3^{2-}}(aq)]$.

7. Using the solubility of $\mathbf{FePO_4}(s)$ ($K_{sp} = 1.3 \times 10^{-22}$) and the acidity constants for $\mathbf{H_3PO_4}$, determine if a concentration of $\mathbf{Fe^{3+}}$ of 100. ppm would be sufficient to precipitate 90% of the phosphate from a solution initially containing 1.0×10^{-4} mol L^{-1} of total phosphate at a constant pH of 8.00.

8. Gold ores are frequently leached with cyanide dissolving the gold according to;
$\mathbf{Au}(s) + 2\,\mathbf{CN^-}(aq) + ¼\,\mathbf{O_2}(g) + ½\,\mathbf{H_2O}(l) \;=====\; \mathbf{Au(CN)_2^-}(aq) + \mathbf{OH^-}(aq)$
Which has an equilibrium constant, $K = 1.2 \times 10^{17}$. In order to prevent undue environmental contamination by cyanide, you wish to operate this process under conditions such that at least 98% of the $\mathbf{CN^-}$ is converted to $\mathbf{Au(CN)_2^-}$. Your process operates at a pH 9.0 and the $\mathbf{O_2}$ pressure inside the ore body is constant at 0.032 atm. Calculate the molar concentration of $\mathbf{CN^-}$ required.

9. Filter alum $\mathbf{Al_2(SO_4)_3}$ is often used to remove phosphate from wastewater. A wastewater of pH 5.62 containing 25 ppm total phosphate is treated with alum until the equilibrium concentration of $\mathbf{Al^{3+}}$ is 4.0×10^{-9} mol L^{-1}. What fraction of the phosphate is precipitated as $\mathbf{AlPO_4}(s)$? Consider only the equilibria below;

$\mathbf{AlPO_4}(s) \;====\; \mathbf{Al^{3+}}(aq) + \mathbf{PO_4^{3-}}(aq)$	$K_{sp} = 1.0 \times 10^{-21}$
$\mathbf{H_2PO_4^-}(aq) \;====\; \mathbf{HPO_4^{2-}}(aq) + \mathbf{H^+}(aq)$	$K_a = 6.2 \times 10^{-8}$
$\mathbf{HPO_4^{2-}}(aq) \;====\; \mathbf{PO_4^{3-}}(aq) + \mathbf{H^+}(aq)$	$K_a = 4.8 \times 10^{-13}$

10. Lead solder on copper plumbing has been suggested as a possible source of low levels of lead (II) ions in drinking water. Using the standard reduction tables and the Nernst equation, comment on the possibility of $\mathbf{Pb^{2+}}$ being present at or above the MAC of 10. ppb, if the water in contact with $\mathbf{Pb}(s)$ contains $\mathbf{Cu^{2+}}$ at 0.10 ppm (*ignore* Cu^+ *ions*).