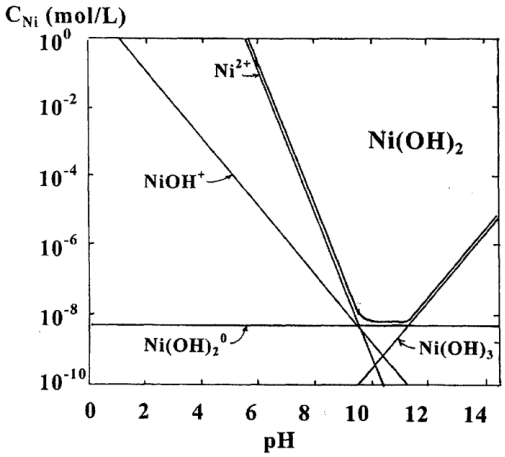
ANSWER ALL QUESTIONS IN SPACE PROVIDED SHOWING YOUR WORK
Total Marks = 40

1. The log concentration of **Ni**(II) species in water is depicted below as a function of pH.

a) Estimate the fractional abundance of $\mathbf{NiOH^+}$ at pH = 9.5? [1]

b) Which is more acidic $\mathbf{Ni^{2+}}$ or $\mathbf{NiOH^+}$? [1]



2. Derive an expression for the saturation index of calcium carbonate (Ω_{CaCO3}) in terms of the concentration of calcium, the K_{sp}, $[\mathbf{CO_3^{2-}}]_T$ and $[alk]_T$. You may assume that the pH range is between 7 – 9, so that $[alk]_T \sim [\mathbf{HCO_3^-}]$ and that the solution is in equilibrium with atmospheric $\mathbf{CO_2}$. [4]

3. Calculate the aqueous solubility of aluminum in ppm at pH 9.00, if $\mathbf{Al(OH)_3}$(s) dissolves in dilute aqueous sodium hydroxide solution according to the reaction below. [4]

$$\mathbf{Al(OH)_3}(s) + \mathbf{OH^-} \text{ ==== } \mathbf{Al(OH)_4^-} \qquad K_{f4} = 0.89$$

4. a) Compare and contrast any **TWO** of the following pairs, commenting on the *environmental significance*. Illustrate your answer with examples, chemical/structural formula, or mathematical equations as appropriate. [6]

i) Coagulation versus Flocculation
ii) Reductive dissolution versus Oxidative dissolution
iii) Octanol-water partitioning constant (K_{ow}) versus Bio-concentration factor (BCF)

b) For any **TWO** of the following, describe the affect of the specified change using appropriate chemical equilibria to illustrate your answer. [6]

i) increase in P_{CO2} on the solubility of $\mathbf{CaCO_3}$
ii) increase in pH on precipitation of $\mathbf{Fe_3(PO_4)_2}$
iii) presence of hexametaphosphate ($\mathbf{P_6O_{18}^{6-}}$) on the dissolution of calcium stearate $\mathbf{Ca(C_{17}H_{35}CO_2)_2}$(s)

5. What mass of organic matter (represented by the formula **CH_2O**) is enough to consume all of the dissolved oxygen in 1.0 L of water in equilibrium with the atmosphere at 25 ^oC? Would your answer change if the organic matter was represented by the formula **$C_6H_{12}O_6$**? [4]

6. In a lake water sample containing 1.0 x 10^{-3} mol L^{-1} calcium and 500. μg L^{-1} fulvic acid, determine the fraction of the fulvic acid that is bound to calcium. Assume that calcium is the only metal present in significant concentration at a pH of 5. Use 5.0 mmol FA_{CO2}- per gram of FA and $K_f' = 1.0 \times 10^3$. [5]

7. 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 [**Ca^{2+}**] = 4.7 mM by the addition of **$Ca(OH)_2$**. What is the concentration of dissolved phosphorous (as ppm **P**) when it's in equilibrium with precipitated calcium phosphate (K_{sp} **$Ca_3(PO_4)_2$** = 1 x 10^{-24})? [5]

8. Using the Eh-pH diagram below for lead ([**Pb**]$_T$ = 10^{-10}), estimate the value of β_2 for the formation lead (II) hydroxide from **Pb^{2+}** and two **OH^-** ligands. You may assume that all lead (II) species are soluble at this concentration. [4]