(a) Calcium ammonium phosphate (CaNH₄PO₄) dissolves in water according to

\[
CaNH₄PO₄(s) \rightleftharpoons Ca^{2+}(aq) + NH₄^+(aq) + PO₄^{3-}(aq)
\]

for which the value of the solubility product, \(K_{sp}\), has been determined to be \(4.4 \times 10^{-14}\). Calculate the solubility of CaNH₄PO₄ in water. Express your answer in units of molarity, i.e., moles of CaNH₄PO₄ per L of solution.

\[
K_{sp} = [Ca^{2+}][NH₄^+][PO₄^{3-}]
\]

by stoichiometry, \([Ca^{2+}] = [NH₄^+] = [PO₄^{3-}] = C_s\)

\[
\therefore K_{sp} = (C_s)^3
\]

\[
\therefore C_s = \left( \frac{K_{sp}}{3.3 \times 10^{-8}} \right) = 3.53 \times 10^{-5} M
\]

(b) Calculate the solubility of CaNH₄PO₄ in 2.2 M CaBr₂(aq). Express your answer in units of molarity. Assume that in water CaBr₂ completely dissociates into \(Ca^{2+}\) cations and \(Br^-\) anions.

\[
CaBr₂ = Ca^{2+} + 2Br^- \therefore [Ca^{2+}] \text{from CaBr₂} = 2.2 M
\]

2.2 M >> \(C_s\) from part (a) which sets \([Ca^{2+}]\) from dissolution of salt in pure water

\[
\text{Assume that } [NH₄^+] = [PO₄^{3-}] = C_s \text{ for CaNH₄PO₄ as before}
\]

\[
K_{sp} = [Ca^{2+}][NH₄^+][PO₄^{3-}] = (2.2)(C_s)^2
\]

\[
\therefore C_s = \left( \frac{K_{sp}}{2.2} \right)^{\frac{1}{2}} = \left( \frac{4.4 \times 10^{-14}}{2.2} \right)^{\frac{1}{2}} = 1.41 \times 10^{-7} M
\]
(a) You have 333 mL of alkaline solution at pH = 9.9. You wish to neutralize this by reacting it with 222 mL of acid. What must be the value of the pH of the acid?

\[
\begin{align*}
333 \text{ mL} \times 9.9 + 222 \text{ mL} \times y &= 555 \text{ mL} \times 7.0 \\
3297 + 222y &= 3885 \\
y &= 2.6
\end{align*}
\]

There's probably an elegant way to do this.

(b) Name the conjugate base of each of the following:

1. \(\text{HPO}_4^{2-}\)  
   \(\text{PO}_4^{3-}\)

2. \(\text{CH}_3\text{NH}_3^+\)  
   \(\text{CH}_3\text{NH}_2\)

(c) Classify each of the following as a Lewis acid or a Lewis base:

1. \(\text{CN}^-\)  
   \(\text{base}\)

2. \(\text{H}_2\text{O}\)  
   \(\text{base}\)

(d) Consider the effect each of the following substances has on the ionization of the weak base, ammonia \((\text{NH}_3(\text{aq}))\). For each, state whether the substance (1) suppresses ionization, (2) enhances ionization, or (3) has no effect on the ionization of ammonia. In each instance, give a reason for your choice.

(i) \(\text{KOH}\)  
   suppressed ionization — The presence of \(\text{OH}^-\) raises pH reducing the capacity of the solution to make available \(\text{H}_3\text{O}^+\) to ionize \(\text{NH}_3\)

(ii) \(\text{HCl}\)  
   enhanced ionization — The presence of \(\text{H}_3\text{O}^+\) calls for proton acceptor according to the Chaterick

(iii) \(\text{NH}_4\text{Cl}\)  
   suppressed ionization — The presence of \(\text{NH}_4^+\) cations had a "common ion effect" which suppresses ionization of \(\text{NH}_3\).