3.091 OCW Scholar

Self-Assessment Exam
Aqueous Solutions

Solution Key

2009 Exam 3, Problem #3

(a) Calcium ammonium phosphate ($CaNH_4PO_4$) dissolves in water according to

$$CaNH_4PO_4(s) \prod Ca^{2+}(aq) + NH_4^+(aq) + PO_4^{3-}(aq)$$

for which the value of the solubility product, K_{sp}, has been determined to be 4.4×10^{-14}. Calculate the solubility of $CaNH_4PO_4$ in water. Express your answer in units of molarity, i.e., moles of $CaNH_4PO_4$ per L of solution.

$K_{sp} = [Ca^{2+}][NH_4^+][PO_4^{3-}]$

solubility of the salt in water

by stoichiometry, $[Ca^{2+}] = [NH_4^+] = [PO_4^{3-}] = c_s$

$\therefore K_{sp} = (c_s)^3$

$\therefore c_s = (K_{sp})^{1/3} = 3.53 \times 10^{-5}\ M$

(b) Calculate the solubility of $CaNH_4PO_4$ in 2.2 M $CaBr_2(aq)$. Express your answer in units of molarity. Assume that in water $CaBr_2$ completely dissociates into Ca^{2+} cations and Br^- anions.

- $CaBr_2 = Ca^{2+} + 2Br^-$ $\therefore [Ca^{2+}]$ from $CaBr_2 = 2.2\ M$
- $2.2\ M >> c_s$ from part (a) which sets $[Ca^{2+}]$ from dissolution of salt in pure water
- assume that $[NH_4^+] = [PO_4^{3-}] = c_s$ of $CaNH_4PO_3$ as before

$\Rightarrow K_{sp} = [Ca^{2+}][NH_4^+][PO_4^{3-}] = (2.2)(c_s)^2$

$\Rightarrow c_s = \left(\frac{K_{sp}}{2.2}\right)^{1/2} = \left(\frac{4.4 \times 10^{-14}}{2.2}\right)^{1/2} = 1.41 \times 10^{-7}\ M$

Final Exam, Problem #10

(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 *p*H of the acid?

$333\ mL \times 9.9 + 222\ mL \times y = 555\ mL \cdot 7.0$

$3297 + 222y = 3885$

$y = 2.06$

There's probably an elegant way to do this.

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

(1) HPO_4^{2-} PO_4^{3-}

(2) $CH_3NH_3^+$ CH_3NH_2

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

(1) CN^- base

(2) H_2O base

(d) Consider the effect each of the following substances has on the ionization of the weak base, ammonia ($NH_3(aq)$). 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) KOH suppresses ionization – the presence of OH^- raises pH reducing the capacity of the solution to make available H^+ to ionize NH_3

(ii) HCl enhanced ionization – the presence of H^+ calls for proton acceptor according to Le Chatelier

(iii) NH_4Cl suppresses ionization – the presence of NH_4^+ cations has a "common ion effect" which represses ionization of NH_3.

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