

Answer on Question #63480 - Chemistry – General Chemistry

In the qualitative analysis scheme, magnesium and nickel precipitate from solution upon the addition of sodium hydroxide. Once separated from the remaining cations by filtration or decanting, the solid mixture is acidified and warmed to dissolve magnesium and nickel cations back into solution. Adding ammonia creates a buffer solution. (Remember, HCl and NH₃ makes for NH₄⁺ cation.) The buffered solution should just be basic (say, pH = 8). Adding sodium hydrogen phosphate (Na₂HPO₄) precipitates magnesium as MgNH₄PO₄ (K_{sp} = 3 × 10⁻¹³).

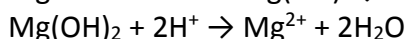
$$K_{sp} = [\text{Mg}^{2+}] \cdot [\text{NH}_3] \cdot [\text{HPO}_4^{2-}] = 3 \times 10^{-13}.$$

$$\text{Molar solubility} = 6.7 \times 10^{-5} \text{ M}$$

a) Calculate the [NH₄⁺] in a pH of 8.

b) Calculate the molar solubility of MgNH₄PO₄ in a solution with pH of 8.

Solution.



a) pH = 8



$$V(\text{solution}) = 1 \text{ L}; n_0(\text{NH}_3) = 1 \text{ mol}; C_0(\text{NH}_3) = 1 \text{ mol/L}$$

$$C(\text{NH}_4^+) = x \text{ mol/L}; C(\text{NH}_3) = (1-x) \text{ mol/L}$$

$$pH = pK_{a, \text{NH}_4^+} - \lg \frac{C_{\text{NH}_4^+}}{C_{\text{NH}_3}}$$

$$K_{b, \text{NH}_3} = 1.76 \cdot 10^{-5}; pK_{b, \text{NH}_3} = -\lg K_{b, \text{NH}_3} = -\lg (1.76 \cdot 10^{-5}) = 4.75;$$

$$pK_{a, \text{NH}_4^+} = pK_w - pK_{b, \text{NH}_3} = 14 - 4.75 = 9.25$$

$$pH = 9.25 - \lg \frac{x}{1-x} = 8$$

$$x = (1-x) \times 17.78$$

$$x = 17.78 - 17.78x$$

$$18.78x = 17.78$$

$$x = 0.95 \text{ mol/L}$$

$$[\text{NH}_4^+] = 0.95 \text{ mol/L}$$

b) $K_{sp} = [\text{Mg}^{2+}] \cdot [\text{NH}_4^+] \cdot [\text{PO}_4^{3-}] = 3 \times 10^{-13}$

$$K_{sp} = S \times 0.95 \times S = 3 \times 10^{-13}$$

$$S = \sqrt{\frac{K_{sp}}{0.95}} = \sqrt{\frac{3 \times 10^{-13}}{0.95}} = 5.6 \times 10^{-7} \text{ M}$$

Answer: a) [NH₄⁺] = 0.95 mol/L

b) S = 5.6 × 10⁻⁷ M

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