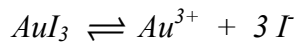
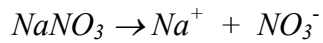


What is the solubility of gold(III) iodide in 0.02 M NaNO₃?



$$\mu = \frac{1}{2} \Sigma(z^2[\text{ion}]) = \frac{1}{2} [1^2 \cdot 0.02 + 1^2 \cdot 0.02] = 0.02 \text{ M}$$

$$K_{sp} = A_{\text{Au}} A_{\text{I}}^3 = \gamma_{\text{Au}} [\text{Au}^{3+}] (\gamma_{\text{I}} [\text{I}^-])^3 = 1.0 \times 10^{-46}$$

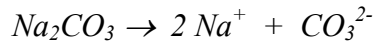
$\gamma_{\text{Au}} = 0.405$ (best guess based on other +3 metal ions and interpolating between 0.445 and 0.245)

$$\gamma_{\text{I}} = 0.805$$

$$1.0 \times 10^{-46} = (0.405x)(0.805 \cdot 3x)^3 = 5.70x^4$$

$$2.0 \times 10^{-12} = x = \text{solubility}$$

What is the solubility of CaCO₃ in 0.010 M Na₂CO₃?



$$\mu = \frac{1}{2} \sum z^2 [\text{ion}] = \frac{1}{2} [1^2 \cdot 0.02 + 2^2 \cdot 0.01] = 0.030 \text{ M}$$

$$K_{sp} = A_{\text{Ca}} A_{\text{CO}_3} = \gamma_{\text{Ca}} [\text{Ca}^{2+}] \gamma_{\text{CO}_3} [\text{CO}_3^{2-}] = 4.8 \times 10^{-9}$$

$$\gamma_{\text{Ca}} = 0.580 \text{ (half way between 0.01 and 0.5 ionic strengths)}$$

$$\gamma_{\text{CO}_3} = 0.560$$

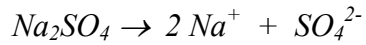
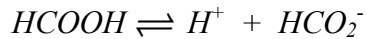
$$4.8 \times 10^{-9} = [.580x][0.560(0.01 + x)]$$

assume x is small

$$4.8 \times 10^{-9} = 0.580x(0.560)(0.01) = 0.00325x$$

$$1.5 \times 10^{-6} \text{ mol/L} = x = \text{solubility}$$

What is the pH of 0.10 M HCOOH in 0.001 M Na₂SO₄?



$$\mu = \frac{1}{2} \sum z^2 [\text{ion}] = \frac{1}{2} [1^2 \cdot 0.002 + 2^2 \cdot 0.001] = 0.003 \text{ M}$$

$$K_a = A_H A_{\text{HCO}_2} / A_{\text{HCOOH}} = \gamma_H [\text{H}^+] \gamma_{\text{HCO}_2} [\text{HCO}_2^-] / \gamma_{\text{HCOOH}} [\text{HCOOH}]$$

$$\gamma_H = 0.950$$

$$\gamma_{\text{HCO}_2} = 0.945$$

$$\gamma_{\text{HCOOH}} = 1 \text{ (all nonions have } \gamma = 1)$$

$$1.8 \times 10^{-4} = 0.950(x)0.945(x)/(0.10-x)$$

$$2.0 \times 10^{-4} = x^2/(0.01-x)$$

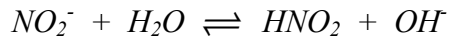
$$2.0 \times 10^{-5} - 2.0 \times 10^{-4}x = x^2$$

$$0 = x^2 + 2.0 \times 10^{-4}x - 2.0 \times 10^{-5}$$

$$x = [(-2.0 \times 10^{-4}) + \sqrt{(2.0 \times 10^{-4})^2 + 4(2.0 \times 10^{-5})}]/2 = 4.4 \times 10^{-3} = [\text{H}^+]$$

$$\text{pH} = -\log A_H = -\log (0.95 \cdot 4.4 \times 10^{-3}) = 2.38$$

What is the pH of 0.050 M KNO₂?



$$\mu = \frac{1}{2} \sum z^2 [\text{ion}] = \frac{1}{2} [0.05 + 0.05] = 0.050 \text{ M}$$

$$K_b = A_{\text{HNO}_2} \cdot A_{\text{OH}^-} / A_{\text{NO}_2^-} = \gamma_{\text{HNO}_2} [\text{HNO}_2] \gamma_{\text{OH}^-} [\text{OH}^-] / \gamma_{\text{NO}_2^-} [\text{NO}_2^-]$$

$$\gamma_{\text{HNO}_2} = 1 \text{ (not an ion)}$$

$$\gamma_{\text{OH}^-} = 0.81$$

$$\gamma_{\text{NO}_2^-} = 0.805$$

$$K_b = K_w / K_a = 1.0 \times 10^{-14} / 4.5 \times 10^{-4} = 2.2 \times 10^{-11}$$

$$2.2 \times 10^{-11} = (x)(0.81x) / (0.805 \cdot 0.050)$$

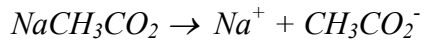
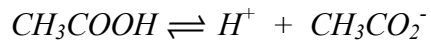
$$1.1 \times 10^{-12} = x^2$$

$$1.0 \times 10^{-6} = x = [\text{OH}^-]$$

$$p\text{OH} = -\log A_{\text{OH}^-} = -\log(0.81 \cdot 1.0 \times 10^{-6}) = 6.07$$

$$p\text{H} = 14.00 - p\text{OH} = 7.93$$

What is the pH of 0.050 M CH₃COOH and 0.050 M NaCH₃CO₂?



$$\mu = \frac{1}{2} [I^2 \cdot 0.05 + I^2 \cdot 0.05] = 0.050 \text{ M}$$

$$K_a = A_H A_{Ac} / A_{HAc} = \gamma_H [H^+] \gamma_{Ac} [Ac] / \gamma_{HAc} [HAc]$$

$$\gamma_H = 0.86$$

$$\gamma_{Ac} = 0.82$$

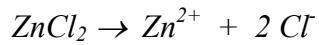
$$\gamma_{HAc} = 1 \text{ (not an ion)}$$

$$1.8 \times 10^{-5} = (0.86x)(0.82 \cdot 0.05) / (0.05)$$

$$2.6 \times 10^{-5} = x = [H^+]$$

$$\text{pH} = -\log (0.86 \cdot 2.6 \times 10^{-5}) = 4.66$$

What is the pH of 0.010 M ZnCl₂?



$$K_a = A_{\text{ZnOH}^+} A_{\text{H}^+} / A_{\text{Zn}^{2+}} = 2.5 \times 10^{-10}$$

$$\mu = \frac{1}{2} [4 \cdot 0.01 + 1 \cdot 0.01] = 0.030 \text{ M}$$

$$\gamma_{\text{Zn}^{2+}} = 0.58 \text{ (half way between values for 0.01 and 0.05)}$$

$$\gamma_{\text{H}^+} = 0.887 \text{ (ditto)}$$

$$\gamma_{\text{ZnOH}^+} = 0.871 \text{ (use the same size as the } \text{Zn}^{2+} \text{ ion, but with the } \pm 1 \text{ line)}$$

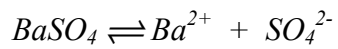
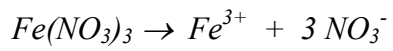
$$2.5 \times 10^{-10} = (0.871x)(0.887x)/(0.58 \cdot 0.01)$$

$$4.3 \times 10^{-6} = x$$

$$A_{\text{H}^+} = (0.887)(4.3 \times 10^{-6}) = 3.8 \times 10^{-6}$$

$$\text{pH} = -\log A_{\text{H}^+} = 5.42$$

What is the solubility of barium sulfate in 0.002 M Fe(NO₃)₃?



$$\mu = \frac{1}{2} [9 \cdot 0.002 + 1 \cdot 0.006] = 0.012 \text{ M}$$

(use 0.01 M as close enough for determining activity coefficients)

$$K_{sp} = A_{Ba} \cdot A_{SO_4}$$

$$1.1 \times 10^{-10} = \gamma_{Ba} [Ba^{2+}] \gamma_{SO_4} [SO_4^{2-}]$$

$$\gamma_{Ba} = 0.67$$

$$\gamma_{SO_4} = 0.660$$

$$1.1 \times 10^{-10} = (0.67)x(0.66)x$$

$$1.6 \times 10^{-5} \text{ mol/L} = x = \text{solubility}$$