What is the solubility of gold(III) iodide in 0.02 M $NaNO_3$?

$NaNO_3 \rightarrow Na^+ + NO_3^-$

$AuI_3 \rightleftharpoons Au^{3+} + 3\,I^-$

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

$Ksp = A_{Au}A_I^3 = \gamma_{Au}[Au^{3+}](\gamma_I[I^-])^3 = 1.0 \times 10^{-46}$

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

$\gamma_I = 0.805$

$1.0 \times 10^{-46} = (0.405x)(0.805 \cdot 3x)^3 = 5.70x^4$
$2.0 \times 10^{-12} = x = solubility$

What is the solubility of $CaCO_3$ in 0.010 M Na_2CO_3?

$CaCO_3 \rightleftharpoons Ca^{2+} + CO_3^{2-}$

$Na_2CO_3 \rightarrow 2\ Na^{+} + CO_3^{2-}$

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

$Ksp = A_{Ca} \cdot A_{CO3} = \gamma_{Ca}[Ca^{2+}]\gamma_{CO3}[CO_3^{2-}] = 4.8 \times 10^{-9}$

$\gamma_{Ca} = 0.580$ *(half way between 0.01 and 0.5 ionic strengths)*
$\gamma_{CO3} = 0.560$

$4.8 \times 10^{-9} = [.580x][0.560(0.01 + x)]$
assume x is small
$4.8 \times 10^{-9} = 0.580x(0.560)(0.01) = 0.00325x$

1.5×10^{-6} *mol/L* $= x =$ *solubility*

What is the pH of 0.10 M HCOOH in 0.001 M Na_2SO_4?

$HCOOH \rightleftharpoons H^+ + HCO_2^-$

$Na_2SO_4 \rightarrow 2\ Na^+ + SO_4^{2-}$

$\mu = ½\ \Sigma z^2[ion] = ½\ [1^2 \cdot 0.002 + 2^2 \cdot 0.001] = 0.003\ M$

$Ka = A_H \cdot A_{HCO2}/A_{HCOOH} = \gamma_H[H^+]\gamma_{HCO2}[HCO_2^-]/\gamma_{HCOOH}[HCOOH]$

$\gamma_H = 0.950$
$\gamma_{HCO2} = 0.945$
$\gamma_{HCOOH} = 1$ (all nonions have $\gamma = 1$)

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

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

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

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

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

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

What is the pH of 0.050 M KNO_2?

$KNO_2 \rightarrow K^+ + NO_2^-$

$NO_2^- + H_2O \rightleftharpoons HNO_2 + OH^-$

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

$K_b = A_{HNO2} \cdot A_{OH} / A_{NO2} = \gamma_{HNO2}[HNO_2]\gamma_{OH}[OH^-] / \gamma_{NO2}[NO_2^-]$

$\gamma_{HNO2} = 1$ *(not an ion)*
$\gamma_{OH} = 0.81$
$\gamma_{NO2} = 0.805$

$Kb = Kw/Ka = 1.0 \times 10^{-14} / 4.5 \times 10^{-4} = 2.2 \times 10^{-11}$

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

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

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

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

$pH = 14.00 - pOH = 7.93$

What is the pH of 0.050 M CH_3COOH and 0.050 M $NaCH_3CO_2$?

$CH_3COOH \rightleftharpoons H^+ + CH_3CO_2^-$
$NaCH_3CO_2 \rightarrow Na^+ + CH_3CO_2^-$

$Ac = CH_3CO_2^-$

$\mu = ½ [1^2 \cdot 0.05 + 1^2 \cdot 0.05] = 0.050\ M$

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

$\gamma_H = 0.86$
$\gamma_{Ac} = 0.82$
$\gamma_{HAc} = 1$ (not an ion)

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

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

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

What is the pH of 0.010 M $ZnCl_2$?

$ZnCl_2 \rightarrow Zn^{2+} + 2\ Cl^-$

$[Zn(H_2O)_6]^{2+} \rightleftharpoons H^+ + [Zn(OH)(H_2O)_5]^+$

$Ka = A_{ZnOH} \cdot A_H / A_{Zn} = 2.5 \times 10^{-10}$

$\mu = ½\ [4 \cdot 0.01 + 1 \cdot 0.01] = 0.030\ M$

$\gamma_{zn} = 0.58$ *(half way between values for 0.01 and 0.05)*
$\gamma_H = 0.887$ *(ditto)*
$\gamma_{ZnOH} = 0.871$ *(use the same size as the* Zn^{2+} *ion, but with the ±1 line)*

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

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

$A_H = (0.887)(4.3 \times 10^{-6}) = 3.8\ X\ 10^{-6}$

$pH = -\log A_H = 5.42$

What is the solubility of barium sulfate in 0.002 M $Fe(NO_3)_3$?

$Fe(NO_3)_3 \rightarrow Fe^{3+} + 3\ NO_3^-$

$BaSO_4 \rightleftharpoons Ba^{2+} + SO_4^{2-}$

$\mu = ½\ [9 \cdot 0.002 + 1 \cdot 0.006] = 0.012\ M$
(use 0.01 M as close enough for determining activity coefficients)

$Ksp = A_{Ba} \cdot A_{SO4}$

$1.1\ X\ 10^{-10} = \gamma_{ba}[Ba^{2+}]\gamma_{SO4}[SO_4^{2-}]$

$\gamma_{Ba} = 0.67$
$\gamma_{SO4} = 0.660$

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

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