Quiz 17.5 – Formation Reactions

Name: Key

Question 1

Copper(II) ions will form a $Cu(NH_3)_4^{2+}$ complex ion with $K_f = 1.7 \times 10^{13}$
Find $[Cu^{2+}]$, $[NH_3]$, and $[Cu(NH_3)_4^{2+}]$ for a solution which is $0.200\ F$ in Cu^{2+} and $0.500\ F$ in NH_3

$Cu^{2+} + 4\,NH_3 \rightleftharpoons Cu(NH_3)_4^{2+}$

	Cu^{2+}	NH_3	$Cu(NH_3)_4^{2+}$
B	0.2	0.5	Ø
C	−0.125	−0.5	+0.125
A	0.075	Ø	0.125

$Cu^{2+} + 4\,NH_3 \rightleftharpoons Cu(NH_3)_4$

	Cu^{2+}	NH_3	$Cu(NH_3)_4$
I	0.075	Ø	0.125
C	+x	+4x	−x
E	0.075+x	+4x	0.125 − x

$0.075M$ $\quad 5.6\cdot10^{-4}M$ $\quad 0.125M$

$K_f = \dfrac{[Cu(NH_3)_4^{2+}]}{[Cu^{2+}][NH_3]^4}$ (small)

$1.7\cdot10^{13} = \dfrac{0.125 - x}{(0.075+x)(4x)^4}$

$x = \left(\dfrac{0.125}{0.075 \cdot 1.7\cdot10^{13} \cdot 4^4}\right)^{1/4}$

$x = 1.40\cdot10^{-4}$

Question 2

Consider the formation of the complex ion $Ag(CN)_2^-$, with $(K_f = 1.0 \times 10^{21})$
Find $[Ag^+]$, $[CN^-]$, and $[Ag(CN)_2^-]$ in a solution prepared by mixing $25.00\ ml$ of $0.075\ M$ $AgNO_3$ with $40.00\ ml$ of $0.100\ M$ NaCN → 65 mL total

→ $0.0385M$ → $0.0288M$

$Ag^+ + 2CN^- \rightleftharpoons Ag(CN)_2^-$

	Ag^+	CN^-	$Ag(CN)_2^-$
B	0.0288	0.0385	Ø
C	−0.0192	−0.0385	+0.0192
A	0.0096	Ø	0.0192

$Ag^+ + 2CN^- \rightleftharpoons Ag(CN)_2^-$

	Ag^+	CN^-	$Ag(CN)_2^-$
I	0.0096	Ø	0.0192
C	+x	+2x	−x
E	0.0096+x	2x	0.0192 − x

$0.0096M$ $\quad 4.5\cdot10^{-11}M$ $\quad 0.019M$

$K_f = \dfrac{[Ag(CN)_2^-]}{[Ag^+][CN^-]^2}$ (small)

$1.0\cdot10^{21} = \dfrac{0.0192 - x}{(0.0096+x)(2x)^2}$

$x = \sqrt{\dfrac{0.0192}{0.0096 \cdot 4 \cdot 1.0\cdot10^{21}}}$

$x = 2.24\cdot10^{-11}$

Question 3

PbI_2 is a sparingly soluble salt with $K_{sp} = 9.8 \times 10^{-9}$, while PbI_4^{2-} is a complex ion with $K_f = 3.0 \times 10^4$
What effect does the formation reaction have on the molar solubility of PbI_2?
(Bonus for the truly adventurous!: Find $[Pb^{2+}]$, $[I^-]$, and $[PbI_2^{2-}]$ if excess $PbI_2(s)$ is placed in pure water)

It will increase the solubility as dissolved Pb^{2+} and I^- are consumed to produce PbI_4^{2-}

$PbI_2(s) \rightleftharpoons Pb^{2+} + 2I^-$ ⋮ $Pb^{2+} + 4\,I^- \rightleftharpoons PbI_4^{2-}$

		I^-	Pb^{2+}	I^-	PbI_4^{2-}
I		Ø	x	2x	Ø
C	+x	+2x	−y	−4y	+y
E	x − y	2x − 4y	x − y	2x − 4y	y

$9.8\cdot10^{-9} = (x-y)(2x-4y)^2$

$3.0\cdot10^{4} = \dfrac{y}{(x-y)(2x-4y)^4}$

2 solutions

$x = 0.00135$ ⋮ $x = 850.34$

$y = 2.137\cdot10^{-9}$ ⋮ $y = 850.34$

$x - y = 3.39\cdot10^{-15}$