Quiz 15.3 – 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+}	$4\ NH_3$	$Cu(NH_3)_4^{2+}$
B	0.2	0.5	∅
C	−0.125	−0.5	+0.125
A	0.075	∅	0.125

	Cu^{2+}	$4\ NH_3$	$Cu(NH_3)_4^{2+}$
I	0.075	∅	0.125
C	+x	+4x	−x
E	0.075+x → 0.075 M	4x → $5.6 \cdot 10^{-4}$ M	0.125−x → 0.125 M

$1.7 \cdot 10^{13} = \dfrac{0.125 - x}{(0.075 + x)(4x)^4}$ (small)

$1.7 \cdot 10^{13} = \dfrac{0.125}{0.075 \cdot 4^4 \cdot x^4}$

$x = 1.70 \cdot 10^{-4}$

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 → 65.00 ml
→ 0.02885 M
of $0.100\ M$ NaCN → 0.06154 M

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

	Ag^+	$2CN^-$	$Ag(CN)_2^-$
B	0.02885	0.06154	∅
C	−0.02885	−0.05769	+0.02885
A	∅	0.00385	0.02885

	Ag^+	$2CN^-$	$Ag(CN)_2^-$
I	∅	0.00385	0.0288
C	x	+2x	−x
E	x → $1.9 \cdot 10^{-18}$ M	0.00385+2x → 0.00385 M	0.0288−x → 0.0288 M

$1.0 \cdot 10^{21} = \dfrac{0.0288 - x}{x \cdot (0.00385 + 2x)^2}$

if x is small

$1.0 \cdot 10^{21} = \dfrac{0.0288}{x \cdot 0.00385^2}$

$x = 1.9 \cdot 10^{-18}$

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 solubility as dissolved Pb^{2+} and I^- ions are consumed to produce PbI_4^{2-}

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

I	∅	∅	x	2x	∅
C	+x	+2x	−y	−4y	+y
E	x−y	2x−4y	x−y	2x−4y	y

$9.8 \cdot 10^{-9} = (x - y)(2x - 4y)^2$

$3.0 \cdot 10^4 = \dfrac{y}{(x - y)(2x - 4y)^4}$

2 solutions

x = 0.00135	x = 850.34
$y = 2.17 \cdot 10^{-9}$	y = 850.34
	$x - y = 3.39 \cdot 10^{-15}$