# Analytical chemistry (5th Edition)

LuMg

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## 1 Chapter 6

1. calculate $\beta$ of each:

$$\begin{aligned}
\beta &= 1.59 * 10^{14} \\
\beta &= 2.19 * 10^{16} \\
\beta &= 9.87 * 10^{19} \\
\beta &= 2.82 * 10^{16} \\
\beta &= 10^{3.2} \\
\beta &= 10^{18.80} \\
\beta &= 2.51 * 10^{15}
\end{aligned} \tag{1}$$

2. There are three kinds:

$$\begin{aligned}
\alpha Cu\left(C_2O_4\right) &= 1 + \left[C_2O_4^{2-}\right] * \beta_{1,CuC_2O_4^{2-}} + \left[C_2O_4^{2-}\right]^2 * \beta_{2,Cu\left(C_2O_4^{2-}\right)_2} = 10^{7.9} \\
\alpha Cu\left(OH\right) &= 1 + \left[OH^-\right] * \beta_{1,Cu(OH)} = 10^{1.26} \\
\alpha Cu\left(NH_3\right) &= 1 + \left[NH_3\right] * \beta_{1,Cu(NH_3)} + \left[NH_3\right]^2 * \beta_{2,Cu(NH_3)_2} + \cdots + \left[NH_3\right]^5 * \beta_{1,Cu(NH_3)_5} = 10^{9.36} \\
\alpha_{total} &= \alpha Cu\left(C_2O_4\right) + \alpha Cu\left(OH\right) + \alpha Cu\left(NH_3\right) - 2 = 10^{9.36}
\end{aligned} \tag{2}$$

3.

$$\begin{aligned}
\alpha Mg &= \alpha Mg\left(OH^-\right) = 1 + \left[OH^-\right] * \beta_{1,Mg(OH^-)} = 1.04 \\
\alpha In &= \alpha In\left(H^+\right) = 1 + \left[OH^-\right] * K_{1,In} + \left[OH^-\right]^2 * K_{2,In} * K_{1,In} = 10^{1.6} \\
lgK^{'}_{MgIn} &= lgK_{MgIn} - lg\alpha In - lg\alpha Mg = 7.0 - 0.017 - 1.6 = 5.4
\end{aligned} \tag{3}$$

4.

- in the first case:

$[NH_3] = 0.01 mol/L$

$$\left[OH^-\right] = 10^{-5} mol/L$$

$$\delta_M = \frac{1}{1 + \beta_{1,NH_3} * [NH_3] + \beta_{2,NH_3} * [NH_3]^2 + \beta_{3,NH_3} * [NH_3]^3 + \beta_{4,NH_3} * [NH_3]^4} = 0.82\%$$

$$\delta_{M(NH_3)} = \frac{\beta_{1,NH_3} * [NH_3]}{1 + \beta_{1,NH_3} * [NH_3] + \beta_{2,NH_3} * [NH_3]^2 + \beta_{3,NH_3} * [NH_3]^3 + \beta_{4,NH_3} * [NH_3]^4} = 0.82\%$$

$$\delta_{M(NH_3)_2} = \frac{\beta_{2,NH_3} * [NH_3]^2}{1 + \beta_{1,NH_3} * [NH_3] + \beta_{2,NH_3} * [NH_3]^2 + \beta_{3,NH_3} * [NH_3]^3 + \beta_{4,NH_3} * [NH_3]^4} = 8.20\%$$

$$\delta_{M(NH_3)_3} = \frac{\beta_{3,NH_3} * [NH_3]^3}{1 + \beta_{1,NH_3} * [NH_3] + \beta_{2,NH_3} * [NH_3]^2 + \beta_{3,NH_3} * [NH_3]^3 + \beta_{4,NH_3} * [NH_3]^4} = 8.20\%$$

$$\delta_{M(NH_3)_4} = \frac{\beta_{4,NH_3} * [NH_3]^4}{1 + \beta_{1,NH_3} * [NH_3] + \beta_{2,NH_3} * [NH_3]^2 + \beta_{3,NH_3} * [NH_3]^3 + \beta_{4,NH_3} * [NH_3]^4} = 81.97\%$$

$$\delta_M = \frac{1}{1 + \beta_{1,OH^-} * [OH^-] + \beta_{2,OH^-} * [OH^-]^2 + \beta_{3,OH^-} * [OH^-]^3 + \beta_{4,OH^-} * [OH^-]^4} = 82.64\%$$

$$\delta_{M(OH^-)} = \frac{\beta_{1,OH^-} * [OH^-]}{1 + \beta_{1,OH^-} * [OH^-] + \beta_{2,OH^-} * [OH^-]^2 + \beta_{3,OH^-} * [OH^-]^3 + \beta_{4,OH^-} * [OH^-]^4} = 8.26\%$$

$$\delta_{M(OH^-)_2} = \frac{\beta_{2,OH^-} * [OH^-]^2}{1 + \beta_{1,OH^-} * [OH^-] + \beta_{2,OH^-} * [OH^-]^2 + \beta_{3,OH^-} * [OH^-]^3 + \beta_{4,OH^-} * [OH^-]^4} = 0.82\%$$

$$\delta_{M(OH^-)_3} = \frac{\beta_{3,OH^-} * [OH^-]^3}{1 + \beta_{1,OH^-} * [OH^-] + \beta_{2,OH^-} * [OH^-]^2 + \beta_{3,OH^-} * [OH^-]^3 + \beta_{4,OH^-} * [OH^-]^4} = 8.26\%$$

$$\delta_{M(OH^-)_4} = \frac{\beta_{4,OH^-} * [OH^-]^4}{1 + \beta_{1,OH^-} * [OH^-] + \beta_{2,OH^-} * [OH^-]^2 + \beta_{3,OH^-} * [OH^-]^3 + \beta_{4,OH^-} * [OH^-]^4} = 0\%$$

(4)

The majority is $M(NH_3)_4$
Given $C_M = 0.1 mol/L$
$[M(NH_3)4] = 0.082 mol/L$

- $\left[OH^-\right] = 0.1mol/L$

$$[NH_3] = 0.01mol/L$$

$$\delta_M = \frac{1}{1+\beta_{1,OH^-} * [OH^-] + \beta_{2,OH^-} * [OH^-]^2 + \beta_{3,OH^-} * [OH^-]^3 + \beta_{4,OH^-} * [OH^-]^4} = 0\%$$

$$\delta_{M(OH^-)} = \frac{\beta_{1,OH^-} * [OH^-]}{1+\beta_{1,OH^-} * [OH^-] + \beta_{2,OH^-} * [OH^-]^2 + \beta_{3,OH^-} * [OH^-]^3 + \beta_{4,OH^-} * [OH^-]^4} = 0\%$$

$$\delta_{M(OH^-)_2} = \frac{\beta_{2,OH^-} * [OH^-]^2}{1+\beta_{1,OH^-} * [OH^-] + \beta_{2,OH^-} * [OH^-]^2 + \beta_{3,OH^-} * [OH^-]^3 + \beta_{4,OH^-} * [OH^-]^4} = 0\%$$

$$\delta_{M(OH^-)_3} = \frac{\beta_{3,OH^-} * [OH^-]^3}{1+\beta_{1,OH^-} * [OH^-] + \beta_{2,OH^-} * [OH^-]^2 + \beta_{3,OH^-} * [OH^-]^3 + \beta_{4,OH^-} * [OH^-]^4} = 50.00\%$$

$$\delta_{M(OH^-)_4} = \frac{\beta_{4,OH^-} * [OH^-]^4}{1+\beta_{1,OH^-} * [OH^-] + \beta_{2,OH^-} * [OH^-]^2 + \beta_{3,OH^-} * [OH^-]^3 + \beta_{4,OH^-} * [OH^-]^4} = 50.00\%$$

(5)

So the majority is $M(OH)_4$
Given $C_M = 0.1mol/L$
$[M(OH)_4] = 0.05mol/L$

5.

*Given* :

$$c_{Ag} = 0.1mol/L$$

$$[L] = 0.01mol/L$$

$$[AgL] = c_{Ag} * \frac{\beta_1 * [L]}{1+\beta_1 * [L] + \beta_2 * [L]^2}$$

$$= 9.09 * 10^{-3} mol/L$$

$$[AgL_2] = c_{Ag} * \frac{\beta_2 * [L]^2}{1+\beta_1 * [L] + \beta_2 * [L]^2} \qquad (6)$$

$$= 0.0909mol/L$$

$$c_L = [L] + [AgL] + 2 * [AgL2]$$

$$= 0.01 + 9.09 * 10^{-3} + 0.0909 * 2 = 0.2mol/L$$

$$\delta_{AgL} = \frac{\beta_1 * [L]}{1+\beta_1 * [L] + \beta_2 * [L]^2} = 9.09\%$$

6.

$$[Cd^{2+}] = 0.01mol/L$$

$$[Zn^{2+}] = 0.01mol/L$$

$$[Y^{4-}] = 0.01mol/L$$

$$[Tart] = 0.1mol/L$$

$$\alpha_{Cd(Tart)} = 1 + \beta_{CdTart} * [Tart] = 10^{1.8}$$

$$\alpha_{Zn(Tart)} = 1 + \beta_{1,ZnTart} * [Tart] + \beta_{2,ZnTart} * [Tart]^2 = 10^{6.32}$$

$$[Zn^{2+}] = \frac{1}{\alpha_{ZnTart}} * c_{Zn} = 10^{-8.32}mol/L$$

$$[Cd^{2+}] = \frac{1}{\alpha_{CdTart}} * c_{Cd} = 10^{-3.8}mol/L \tag{7}$$

$$\alpha_{Y(Zn)} = 1 + K_{ZnY} * [Zn^{2+}] = 10^{8.18}$$

$$\alpha_{Y(Cd)} = 1 + K_{cdY} * [Cd^{2+}] = 10^{12.66}$$

$$So:$$

$$lgK`CdY = lgK_{CdY} - lg\alpha_{CdTart} - lg(\alpha_{Y(Zn)} + \alpha_{Y(H)} - 1)$$
$$= 6.48$$

$$lgK`ZnY = lgK_{ZnY} - lg\alpha_{ZnTart} - lg(\alpha_{Y(Cd)} + \alpha_{Y(H)} - 1)$$
$$= -2.48$$

8. Cd with $I^-$:

$$
\begin{aligned}
lg\beta_1 &= 2.10 \\
lg\beta_2 &= 3.43 \\
lg\beta_3 &= 4.49 \\
lg\beta_4 &= 5.41 \\
\alpha_{Cd(I)} &= 1 + \beta_1 * [I^-] + \beta_2 * [I^-]^2 + \beta_3 * [I^-]^3 + \beta_4 * [I^-]^4 = 10^{5.46} \\
[Cd^{2+}] &= 0.005 mol/L \\
[Cd^{2+}] &= \frac{1}{\alpha_{Cd(I)}} * c_{Cd} = 10^{-7.76} \\
\alpha_{Y(Cd)} &= 1 + K_{CdY} * [Cd^{2+}] = 10^{8.7} \\
lgK'_{ZnY} &= lgK_{ZnY} - lg(\alpha_{Y(Cd)} + \alpha_{Y(H)} - 1) \\
&= 10^{7.8} \\
p_{Znsp} &= \frac{1}{2} * (lgK'_{ZnY} + pC_{Znsp}) \\
&= \frac{1}{2} * (7.8 + p(0.005)) \\
&= 5.05 \\
p_{Znep} &= lgK'_{ZnIn} = 4.8 \\
E_t &= \frac{10^{\delta_{pM}} - 10^{-\delta_{pM}}}{\sqrt{K'_{ZnY} * C^{sp}_{Zn}}} \\
&= \frac{10^{-0.25} - 10^{0.25}}{\sqrt{10^{7.8} * 0.005}} \\
&= -0.22\%
\end{aligned}
\tag{8}
$$

9.$(a)$

$$
\begin{gathered}
0.2\% = \frac{10^{\Delta pM} - 10^{-\Delta pM}}{\sqrt{K_{BiY}^{,} * c_{Bi}^{sp}}} \\
Given: \\
\Delta pM = 0.38 \\
K_{BiY}^{,} * c_{Bi}^{sp} \geq 9.8 * 10^5 \\
c_{Bi}^{sp} = 0.01 mol/L \\
lgK_{BiY}^{,} \geq 7.99 \\
lgK_{BiY} - lg\alpha_{Y(H)} \geq 7.99 Then: \\
lgK_{BiY} = 27.94 \\
lg\alpha_{Y(H)} \leq 19.95 \\
pH = 0.64
\end{gathered}
\tag{9}
$$

$(b)$

$$
\begin{gathered}
Given: \\
\Delta pM = 1.0 \\
K_{BiY}^{,} * c_{Bi}^{sp} \geq 2.45 * 10^7 \\
c_{Bi}^{sp} = 0.01 mol/L \\
lgK_{BiY}^{,} \geq 9.39 \\
lgK_{BiY} - lg\alpha_{Y(H)} \geq 9.39 Then: \\
lgK_{BiY} = 27.94 \\
lg\alpha_{Y(H)} \leq 18.55 \\
pH = 0.90
\end{gathered}
\tag{10}
$$

10.

$$
\begin{gathered}
pH = 3.5 \\
lg\alpha_{Y(H)} = 9.48 \\
lg\alpha_{Al(OH)} = 1 \\
\beta^{,} = lgK_{AlY} - lg\alpha_{Y(H)} = 6.82
\end{gathered}
\tag{11}
$$

11.

- $Hg^{2+}$ with $I^-$:

$$
\begin{aligned}
lg\beta_1 = 12.87 \\
lg\beta_2 = 23.82 \\
lg\beta_3 = 27.60 \\
lg\beta_4 = 29.83 \\
[I^-] = 0.01 mol/L \\
[Cd^{2+}] = 0.01 mol/L \\
[Hg^{2+}] = 0.01 mol/L \\
[Y] = 0.01 mol/L \\
\alpha_{Hg(I)} = 1 + \beta_1 * [I^-] + \beta_2 * [I^-]^2 + \beta_3 * [I^-]^3 + \beta_4 * [I^-]^4 \\
= 1.08 * 10^{22} \\
[Hg^{2+}] = \frac{1}{\alpha_{Hg(I)}} * c_{Hg} = 9.26 * 10^{-25} mol/L \\
\alpha_{Y(Hg)} = 1 + K_{HgY} * [Hg^{2+}] = 1 \\
lg\alpha Y(H) = 4.65 \\
lg\beta_{1,CdI} = 2.10 \\
lg\beta_{2,CdI} = 3.43 \\
lg\beta_{3,CdI} = 4.49 \\
lg\beta_{4,CdI} = 5.41 \\
\alpha_{Cd(I)} = 1 + \beta_{1,CdI} * [I^-] + \beta_{2,CdI} * [I^-]^2 + \beta_{3,CdI} * [I^-]^3 + \beta_{4,CdI} * [I^-]^4 = 10^{0.41} \\
lgK^{'}_{CdY} = lgK_{CdY} - lg(\alpha_{Y(H)}) - lg\alpha_{Cd(I)} = 11.40
\end{aligned}
\tag{12}
$$

- $[Hg^{2+}]$ is too low:

$$
[Hg^{2+}] = \frac{1}{\alpha_{Hg(I)}} * c_{Hg} = 9.26 * 10^{-25} mol/L \tag{13}
$$

-

$$
\begin{aligned}
p_{Cdsp} = \frac{1}{2} * (lgK^{'}_{CdY} + p^{sp}_{C_{Cd}}) \\
= \frac{1}{2} * (11.40 + p(0.01)) = 6.7 \\
p_{Cdep} = lgK^{'}_{CdIn} = 5.5 \\
\Delta p_{Cd} = -1.2 \\
E_t = \frac{10^{\Delta p_{Cd}} - 10^{-\Delta p_{Cd}}}{\sqrt{K^{'}_{CdY}} * c^{sp}_{Cd}} \\
= -0.03\%
\end{aligned}
\tag{14}
$$

- $$[I^-] = 0.5mol/L$$
$$\alpha_{Cd(I)} = 1 + \beta_{1,CdI} * [I^-] + \beta_{2,CdI} * [I^-]^2 + \beta_{3,CdI} * [I^-]^3 + \beta_{4,CdI} * [I^-]^4 = 10^{4.3}$$
$$lgK'_{CdY} = lgK_{CdY} - lg(\alpha_{Y(H)}) - lg\alpha_{Cd(I)} = 7.51$$
$$p_{Cdsp} = \frac{1}{2} * (lgK'_{CdY} + p^{sp}_{CCd}) = \frac{1}{2} * (7.51 + p(0.01)) = 4.76$$
$$p_{Cdep} = lgK'_{CdIn} = 5.5$$
$$\Delta p_{Cd} = 0.74$$
$$E_t = \frac{10^{\Delta p_{Cd}} - 10^{-\Delta p_{Cd}}}{\sqrt{K'_{CdY}} * c^{sp}_{Cd}} = 0.93\% \tag{15}$$

12.

- $$[Ac^-] = \frac{K_a}{K_a + [H^+]} * c = 0.2mol/L$$
$$\alpha_{Pb(Ac)} = 1 + \beta_1 * [Ac^-] + \beta_2 * [Ac^-]^2 = 10^{2.43}$$
$$lg\alpha_{Y(H)} = 6.45$$
$$lgK'_{PbY} = lgK_{PbY} - lg\alpha_{Pb(Ac)} - lg\alpha_{Y(H)} = 9.16$$
$$p^{sp}_{Pb} = \frac{1}{2} * (lgK'_{PbY} + p(c^{sp}_{Pb})) = 6.08 \tag{16}$$
$$p^{ep}_{Pb} = lgK'_{PbIn} = lgK_{PbIn} - lg\alpha_{Pb(Ac)} = 7.0 - 2.43 = 4.57$$
$$\Delta p_{Pb} = -1.51$$
$$E_t = \frac{10^{\Delta p_{Pb}} - 10^{-\Delta p_{Pb}}}{\sqrt{K'_{PbY}} * c^{sp}_{Pb}} = -0.27\%$$

- $$\begin{aligned} lgK^{'}_{PbY} &= lgK_{PbY} - lg\alpha_{Y(H)} \\ &= 11.59 \\ p^{sp}_{Pb} &= \frac{1}{2} * (lgK^{'}_{PbY} + p(c^{sp}_{Pb})) = 7.30 \\ p^{ep}_{Pb} &= lgK^{'}_{PbIn} = lgK_{PbIn} = 7.0 \\ \Delta p_{Pb} &= -0.30 \\ E_t &= \frac{10^{\Delta p_{Pb}} - 10^{-\Delta p_{Pb}}}{\sqrt{K^{'}_{PbY} * c^{sp}_{Pb}}} \\ &= -0.008\% \end{aligned} \tag{17}$$

13.

$lg\beta_1 = 4.31$

$$\begin{aligned} lg\beta_2 &= 7.98 \\ lg\beta_3 &= 11.02 \\ lg\beta_4 &= 13.32 \\ lg\beta_5 &= 12.86 \\ \alpha_{Cu(NH_3)} &= 1 + \beta_1 * [NH_3] + \beta_2 * [NH_3]^2 + \beta_3 * [NH_3]^3 + \beta_4 * [NH_3]^4 + \beta_5 * [NH_3]^5 \\ &= 2.27 * 10^9 \\ [Cu^{2+}] &= \frac{1}{\alpha_{Cu(NH_3)}} * c_{Cu} = 4.4 * 10^{-12} mol/L \\ lgK^{'}_{CuY} &= lgK_{CuY} - lg\alpha_{Cu(NH_3)} - lg\alpha_{Y(H)} = 8.99 \\ p^{sp}_{Cu} &= \frac{1}{2} * (lgK^{'}_{CuY} + c^{sp}_{Cu}) \\ &= \frac{1}{2} * (8.99 + p(0.01)) = 5.50 \\ {p^{'}_{Cu}}^{ep} &= p^{ep}_{Cu} - lg(\alpha_{Cu(NH_3)}) = 4.44 \\ \Delta p_{Cu} &= {p^{'}_{Cu}}^{ep} - p^{sp}_{Cu} = -1.06 \\ E_t &= \frac{10^{\Delta p_{Cu}} - 10^{-\Delta p_{Cu}}}{\sqrt{K^{'}_{CuY} * c^{sp}_{Cu}}} = -0.36\% \end{aligned} \tag{18}$$

15.

$$\begin{gathered}[Th] = 0.01mol/L \\ [La] = 0.01mol/L \\ K_{sp,Th(OH)_4} = 10^{-44.89} \\ pOH = 3.5 \\ K_{sp,La(OH)_3} = 10^{-18.8} \\ pOH = 2.56\end{gathered} \tag{19}$$

As long as keep $pH < 7$ we can ignore $OH^-$

$$\begin{gathered}lg\beta_{ThY} = 23.2 \\ lg\beta_{LaY} = 15.5 \\ lg(K^{,}_{ThY} * c^{sp}_{Th}) \geq 6 lgK^{,}_{ThY} \geq 8 \\ lg(\alpha_{Y(H)} + \alpha_{Y(La)} - 1) \leq 15.2 \\ pH \approx 1.6\end{gathered} \tag{20}$$

16.

$$\begin{gathered}EDTA : Zn, Al, Ti \\ C_2H_8N_2 : Zn \\ C_7H_6O_6S : Al, Zn\end{gathered} \tag{21}$$

17.

$$
\begin{gathered}
[F] = 0.1 \\
[CuY] = 0.01 mol/L \\
lg[Cu]_{sp} = -lgK`CuIn = -8.3 \\
[Y]_{ep} = \frac{[CuY]}{[Cu]K`_{CuY}} = \frac{0.01}{10^{11.36} * 10^{-8.3}} = 10^{-5.06} \\
lgK`_{CuY} = lgK_{CuY} - lg\alpha_{Y(H)} = 18.8 - 7.44 = 11.36 \\
lgK`_{FeY} = lgK_{FeY} - lg\alpha_{Y(H)} = 25.1 - 7.44 = 17.66 \\
Reaction: \\
\frac{[FeF_3] * [Y]}{[FeY] * [F^-]^3} \\
= \frac{[FeF_3]}{[Fe] * [F]^3} * \frac{[Fe][Y]}{[FeY]} = \frac{\beta_3}{K`_{FeY}} \\
So: \\
\frac{[FeF_3]}{[FeY]} = \frac{\beta_3}{K`_{FeY}} * \frac{[F]^3}{[Y]} \\
= \frac{10^{12.06}}{10^{17.66}} * \frac{10^{-3}}{10^{-5.06}} \\
= 0.029\%
\end{gathered}
\tag{22}
$$

18.

$$
\begin{gathered}
n_{total} = 50ml * 0.03mol/L - 0.03mol/L * 3mL = 1.41mmol \\
n_{Sn} = 35ml * 0.03mol/L = 1.05mmol \\
P_{Sn} = \frac{n_{Sn} * M_{Sn}}{m_{sample}} = 62.32\% \\
P_{Pb} = \frac{(n_{total} - n_{Sn}) * M_{Pb}}{m_{sample}} = 37.26\%
\end{gathered}
\tag{23}
$$

19.

$$
\begin{aligned}
P_{ZrO_2} &= \frac{0.01mol/L * 10mL * \frac{200mL}{50mL} * M_{ZrO2}}{m_{sample}} = 4.92\% \\
P_{Fe_2O_3} &= \frac{0.01mol/L * 20mL * \frac{200mL}{50mL} * \frac{1}{2} * M_{Fe_2O_3}}{m_{sample}} = 6.40\%
\end{aligned}
\tag{24}
$$

20.

$$
P_M = \frac{\frac{50mL}{20mL} * (5mL * 0.3mol/L - \frac{20mL+5mL}{10mL} * 6mL * 0.05mol/L) * 194.16g/mol}{0.5g} = 72.81\%
\tag{25}
$$

21.

$$P_M = \frac{2 * (25.00mL * 0.03000mol/L - \frac{250mL}{25mL} * (0.01mol/L * 3.6mL)) * 254.2g/mol}{0.2014g} = 98.44\% \tag{26}$$

22. When $pH = 1$:

$$\begin{aligned} \beta_{Bi^{3+}} &= 10^{5.3} \\ \beta_{Pb^{2+}} &= 10^{2.4} \\ Bi^{3+} + Y^{4-} &= BiY^- \\ P_{Bi} &= \frac{0.02479 * 25.67 * 5 * M_{Bi}}{1000 * 2.420} = 27.48\% \end{aligned} \tag{27}$$

When $pH = 5$ for both Pb and Cd:

$$\begin{aligned} P_{Cd} &= \frac{0.02174 * 6.76 * 5 * M_{Pb}}{1000 * 2.420} = 3.41\% \\ P_{Pb} &= \frac{(0.02479 * 24.76 - 0.02174 * 6.76) * 5 * M_{Pb}}{1000 * 2.420} = 19.97\% \end{aligned} \tag{28}$$

23.

$$\begin{aligned} (a)[Pb^{2+}][SO_4^{2-}] &= K_{sp} = 1.6 * 10^{-8} \\ \beta &= \frac{[PbY]}{[Pb][Y]} = 1.1 * 10^{18} \\ \frac{[PbY^{2-}]}{[Y^{4-}]} &= 1.4 * 10^4 \end{aligned} \tag{29}$$

So if $[Y^{4-}]$ is large enough, the equation can happen
($b$) Pb will be lower.

$$(c)c_{SO_4^{2-}} = \frac{0.05000mol/L * 50.00mL - 12.24mL * 0.1000mol/L}{25mL} = 0.051mol/L \tag{30}$$

24. Ni remains:

$$\begin{aligned} P_{Ni} &= \frac{0.05831mol/L * 26.14mL * 5 * M_{Ni}}{1000ml/L * m_{sample}} \\ &= 62.33\% \end{aligned} \tag{31}$$