Practice Problem Set Ten

A. Calculate the fraction of each Cd^{+2} containing species and the average number of ligands gained for an uncomplexed iodide concentration of 0.0550 M.

B. If the total cadmium concentration in A is 0.100 M, find the total iodide concentration.

C. Prepare a distribution diagram for I^- with Cd^{+2}. Label each curve with the chemical formula of the species it represents.

D. Calculate the molarity of each silver containing species for a total Ag^+ concentration of 1.00×10^{-4} M in a pH 8.00 solution that contains 0.10 M total NH_3.

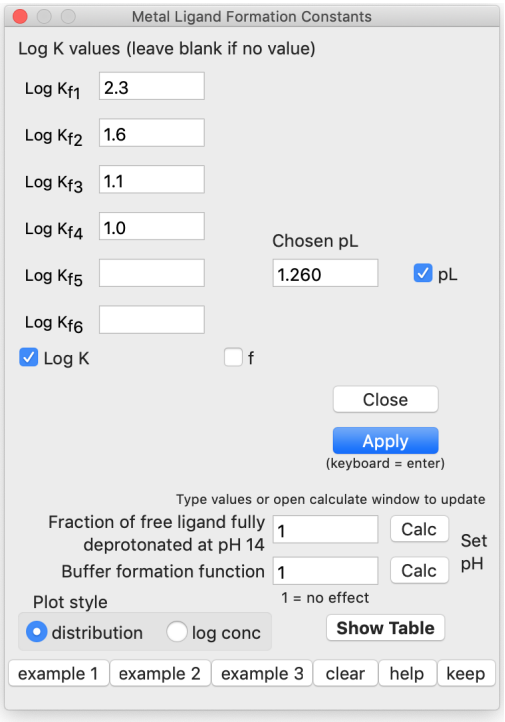
E. What is the value of $[Zn^{+2}]$ in a solution containing 1.4×10^{-6} M total zinc and 1.0×10^{-5} M total ethanediamine at pH 8.50?

F. What is the molarity of each species present in a solution containing 0.020 M Hg^{+2} and 0.30 M ammonia at pH 8.70?

G. What is the molarity of each species present in a solution containing 0.0132 M Pb^{+2} and 0.50 M acetic acid at pH 3.50?

H. Plot the –log of the free metal concentration as a function of the fraction titrated for the titration of 0.0010 M Co^{+2} with 0.0020 M $EDTA^{-4}$ in the presence of 0.30 M NH_3 and 0.10 M NH_4Cl.

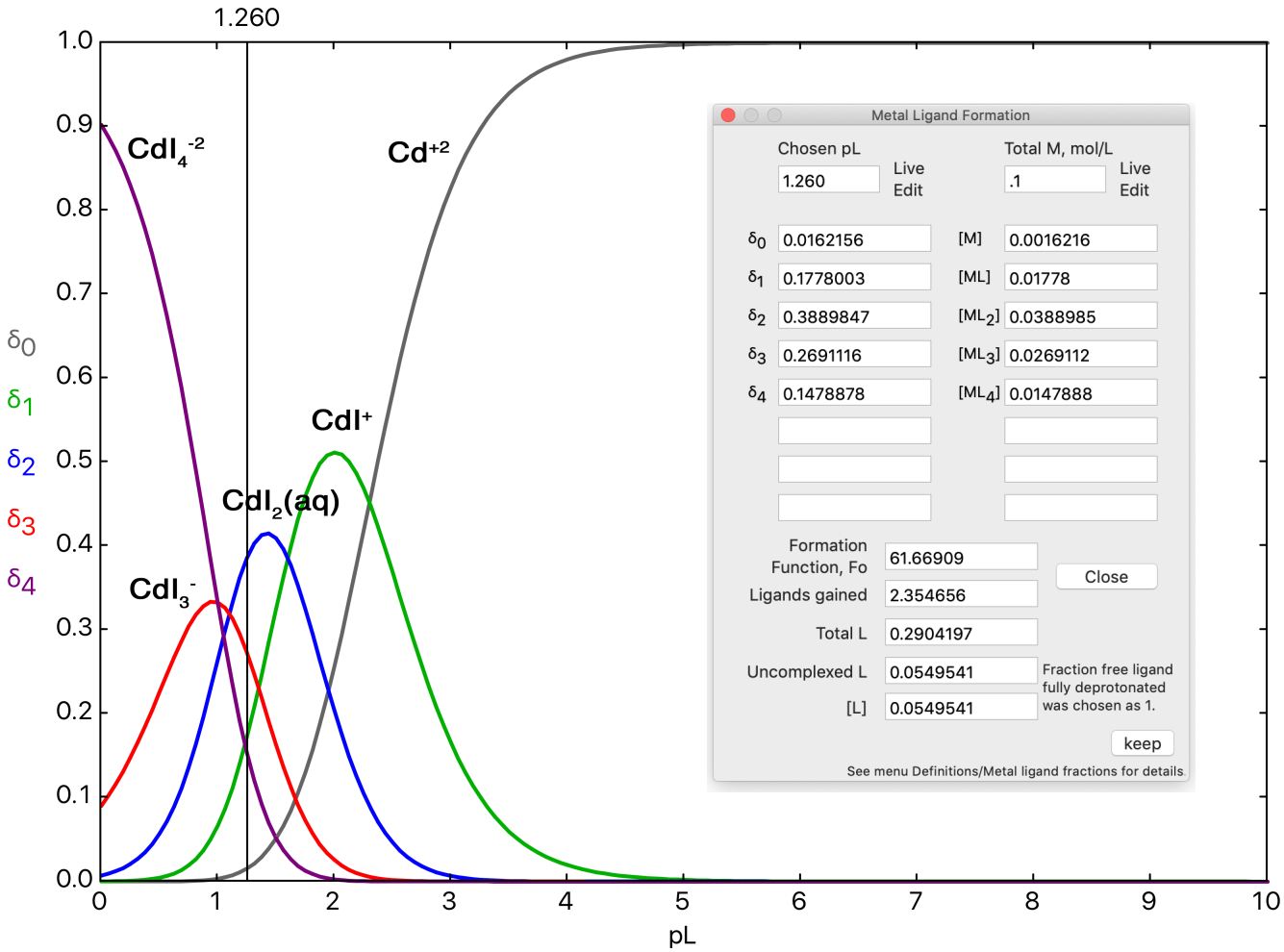
A. We are given $\frac{[L]}{\alpha_n} = 0.0550$. Since HI is a strong monoprotic acid, $\alpha_1 = 1$ (otherwise use the pH to solve for α_n) so $[I^-] = 0.0550$ and pL = 1.260. For Cd^{+2} and I^-, $K_{f1} = 10^{2.3}$, $K_{f2} = 10^{1.6}$, $K_{f3} = 10^{1.1}$, $K_{f4} = 10^{1.0}$. *Solve/delta fractions* (distribution plot style) and click on **Show Table** for results.



$$\delta_0 = \frac{[Cd^{+2}]}{C_M} = 0.0162,\ \delta_1 = \frac{[CdI^+]}{C_M} = 0.178,$$

$$\delta_2 = \frac{[CdI_2(aq)]}{C_M} = 0.389,\ \delta_3 = \frac{[CdI_3^-]}{C_M} = 0.269,$$

$$\delta_4 = \frac{[CdI_4^{-2}]}{C_M} = 0.148, \text{ and } \bar{n} = 2.355$$

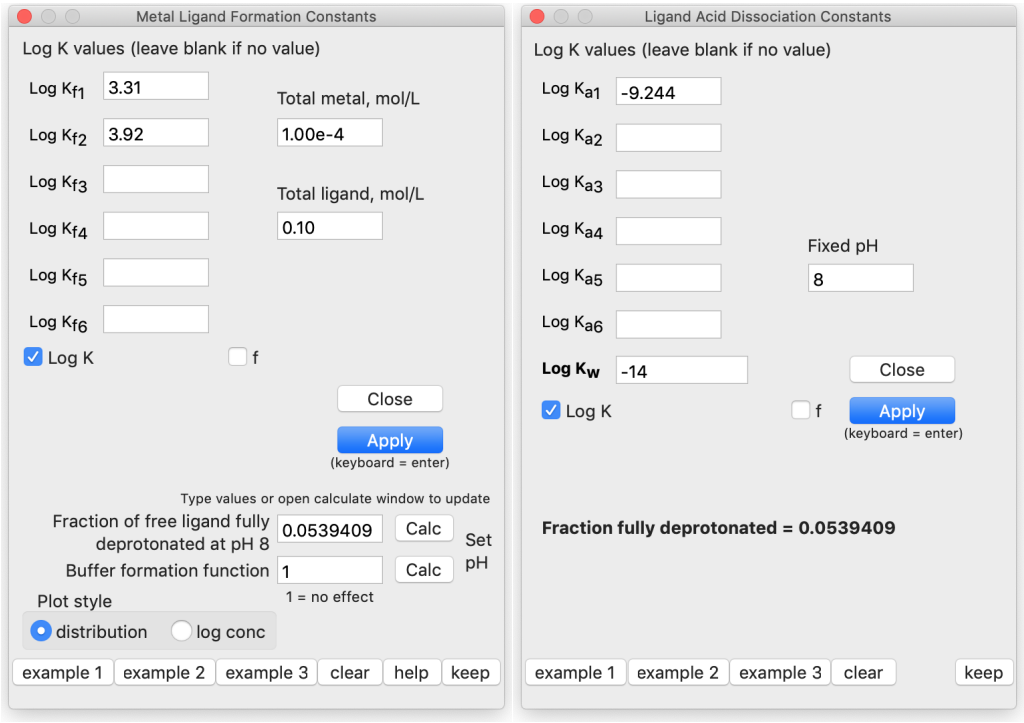


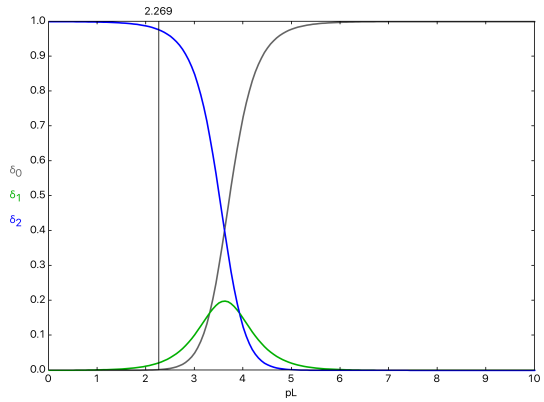
B. If $C_M = 0.100$ M (add to upper right in window above) then the total iodide molarity is

$$C_L = \bar{n}\, C_M + [L]/\alpha_1 = 2.355(0.100) + 0.0550 = 0.290$$

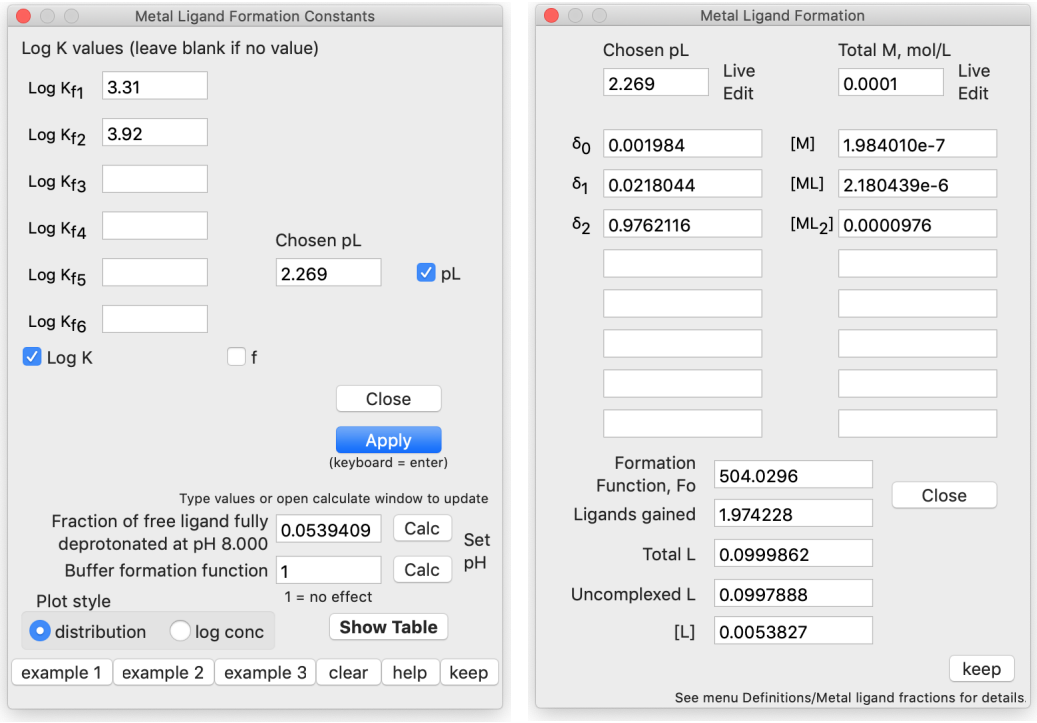
C. *Plot/Distribution vs pL for metal Kf* and label as shown above.

D. *Solve for ligand concentration.* For Ag^+ and NH_3, $K_{f1} = 10^{3.31}$, $K_{f2} = 10^{3.92}$. We are given $C_M = 1.00\times10^{-4}$ M, and $C_L = 0.10$ M. Since NH_3 is a weak monobase, α_n depends on $K_a = 10^{-9.244}$ and pH 8.00. Click the first **Calc button** to find $\alpha_1 = .05394$ so [L]= $\alpha_1(0.10)$ = 0.005394 and pL = 2.269 as displayed on the plot.

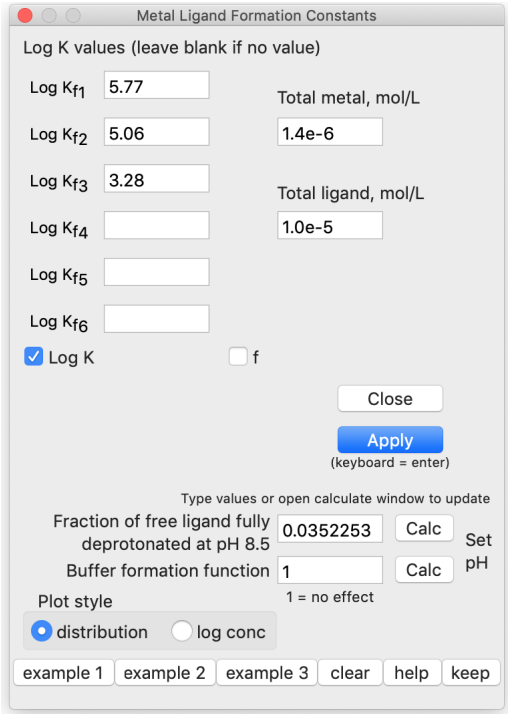


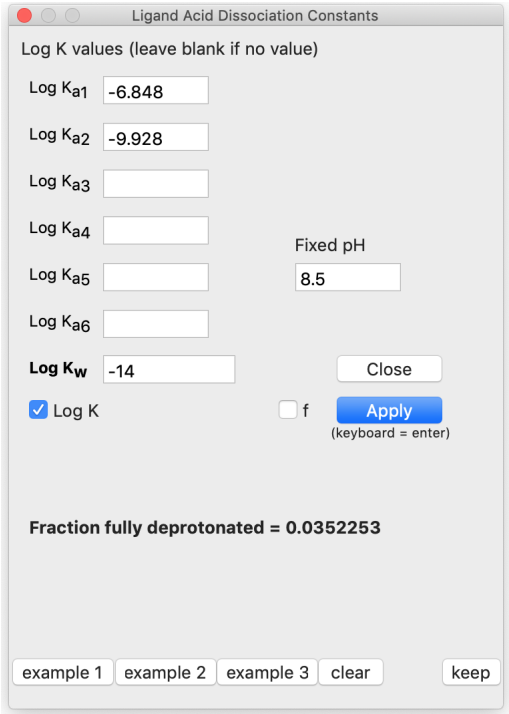


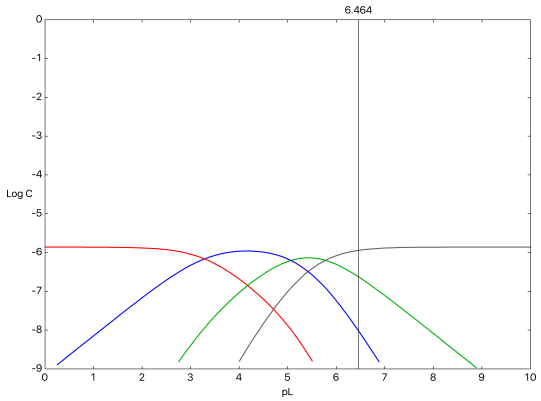
Solve for delta fractions with pL = 2.269 and click **Show Table** to find [Ag^+] = $\delta_0\ C_M = 1.98\times10^{-7}$, [$Ag(NH_3)^+$] = $\delta_1\ C_M = 2.18\times10^{-6}$, [$Ag(NH_3)_2^+$] = $\delta_2\ C_M = 9.76\times10^{-5}$.



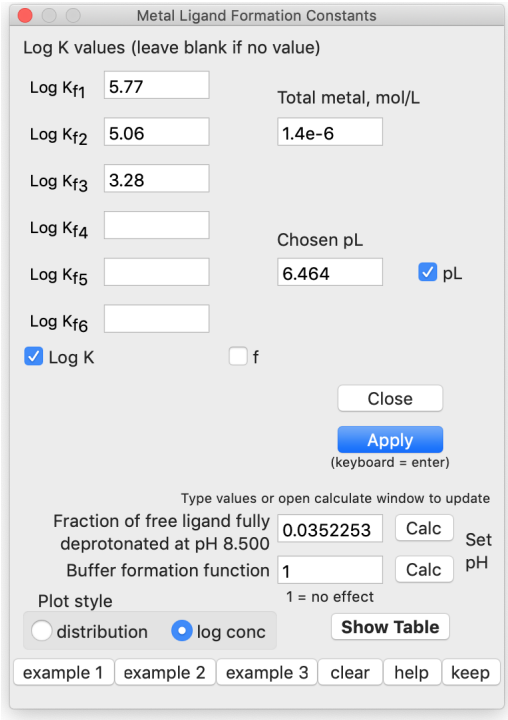
E. *Solve for ligand concentration.* For Zn^{+2} and en, $K_{f1} = 10^{5.77}$, $K_{f2} = 10^{5.06}$, $K_{f3} = 10^{3.28}$. We are given $C_M = 1.4\times10^{-6}$ M, $C_L = 1.0\times10^{-5}$ M. Since en is a weak dibase, α_n depends on $K_{a1} = 10^{-6.848}$, $K_{a2} = 10^{-9.928}$ and pH 8.50. Click the first **Calc button** to find $\alpha_2 = .03523$ and pL = 6.464 at the top of the graph.

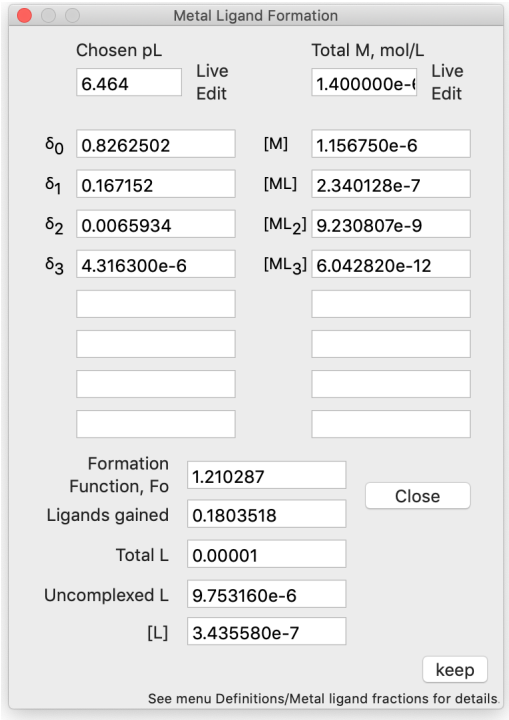






Solve for delta fractions and then **Show Table** to find $[Zn^{+2}] = \delta_0\, C_M = 1.16\times10^{-6}$.

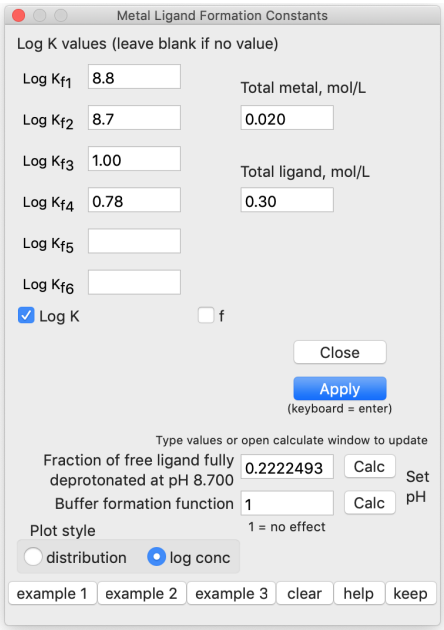


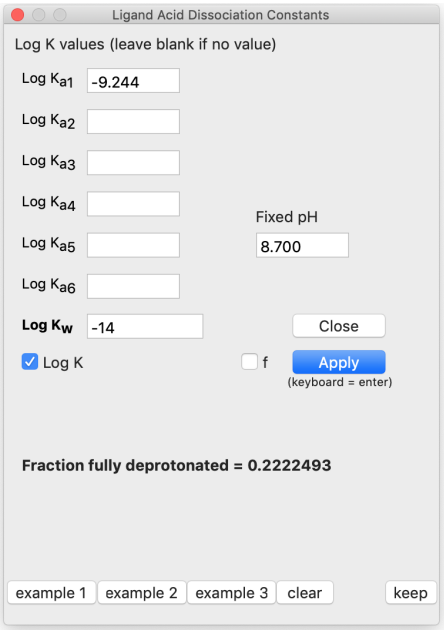


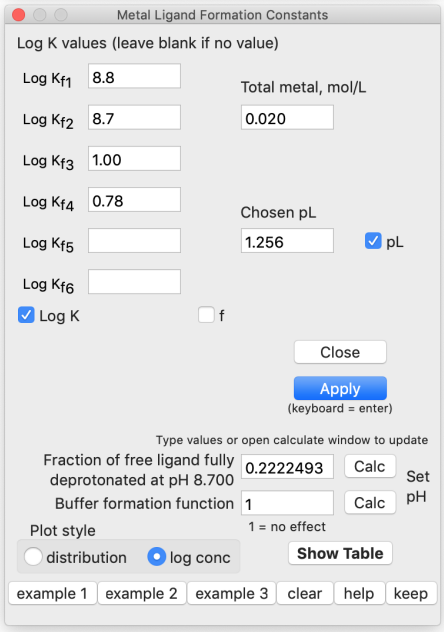
F. *Solve for ligand concentration.*
For Hg^{+2} and NH_3, $K_{f1} = 10^{8.8}$, $K_{f2} = 10^{8.7}$, $K_{f3} = 10^{1.00}$, $K_{f4} = 10^{0.78}$. We are given $C_M = 0.020$ M, $C_L = 0.30$ M. Since NH_3 is a weak monobase, α_n depends on $K_a = 10^{-9.244}$ and pH 8.70. Click the first **Calc button** to find $\alpha_1 = .2222$ and pL = 1.256 at the top of the graph.

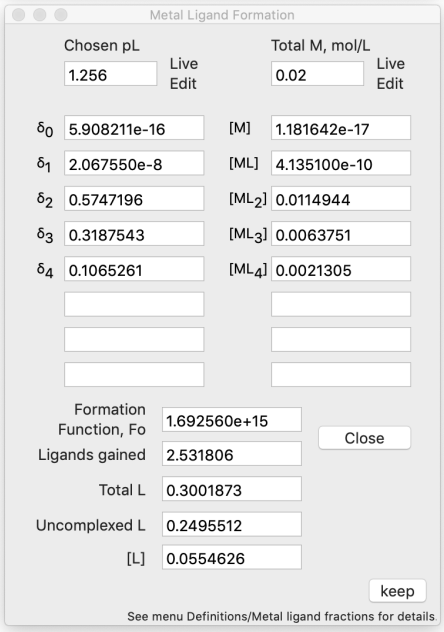
Solve for delta fractions and find $[Hg^{+2}] = \delta_0 C_M = 1.19\times10^{-17}$, $[Hg(NH_3)^{+2}] = \delta_1 C_M = 4.14\times10^{-10}$, $[Hg(NH_3)_2^{+2}] = \delta_2 C_M = 0.0115$, $[Hg(NH_3)_3^{+2}] = \delta_3 C_M = 0.00638$, $[Hg(NH_3)_4^{+2}] = \delta_4 C_M = 0.00213$ and uncomplexed ligand = 0.2496

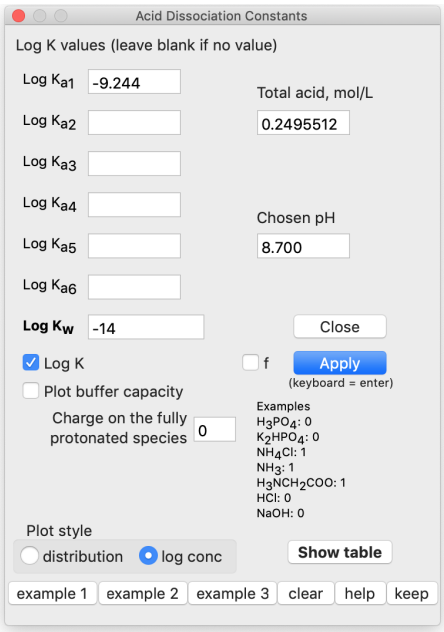
Solve for alpha fractions and **Show Table** to find $\alpha_0 \dfrac{[L]}{\alpha_1} = [NH_4^+] = 0.194$.

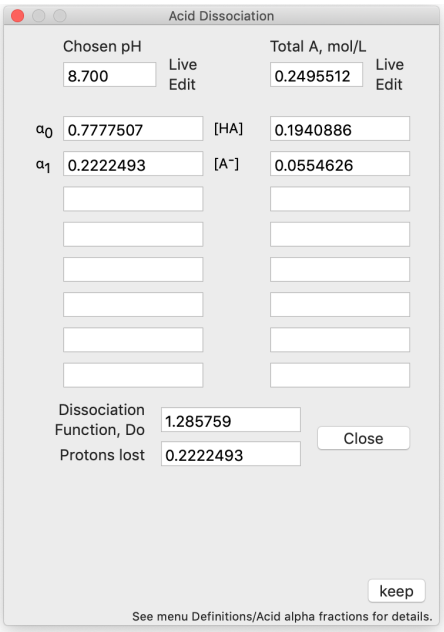








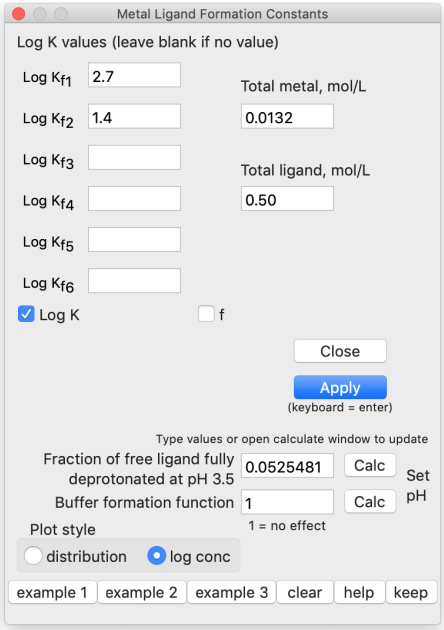


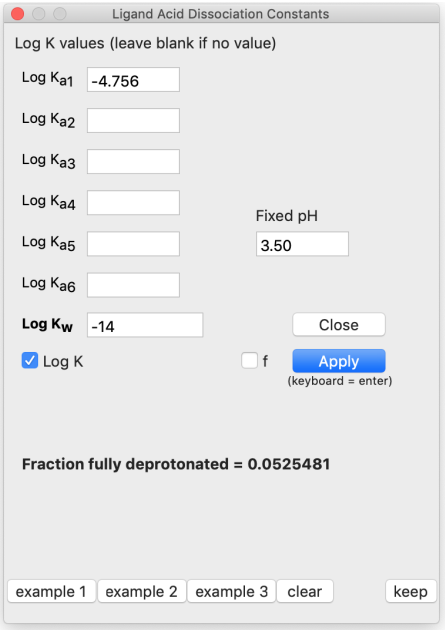


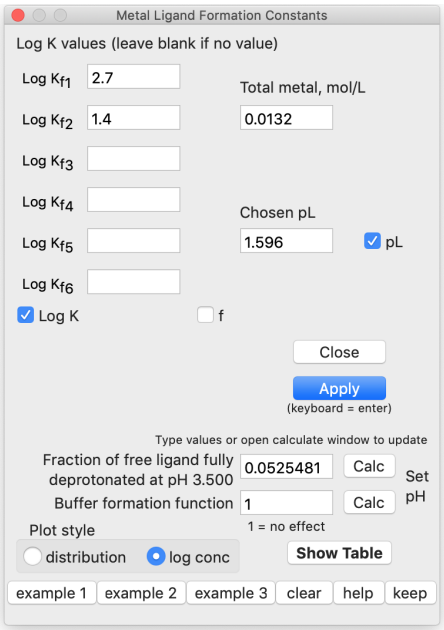
G. *Solve for ligand concentration.* For Pb^{+2} and CH_3COO^-, $K_{f1} = 10^{2.7}$, $K_{f2} = 10^{1.4}$. We are given $C_M = 0.0132$ M, $C_L = 0.50$ M. Since CH_3COO^- is a weak monobase, α_n depends on $K_a = 10^{-4.756}$ and pH 3.50. Click the first **Calc button** to find $\alpha_1 = 0.05255$ and pL = 1.596 at the top of the graph.

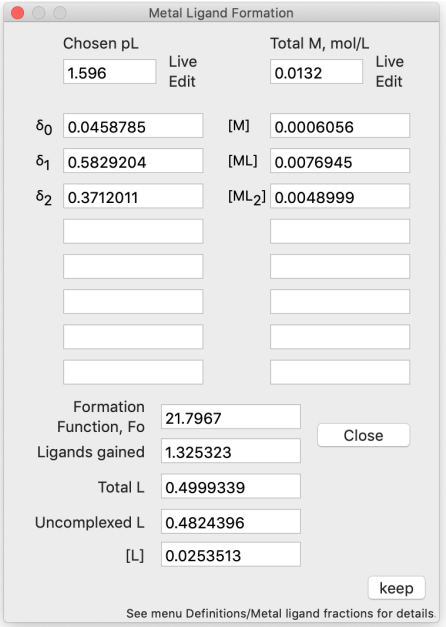
Solve for delta fractions and find $[Pb^{+2}] = \delta_0 C_M = 0.000606$, $[Pb(CH_3COO)^+] = \delta_1 C_M = 0.007691$, $[Pb(CH_3COO)_2(aq)] = \delta_2 C_M = 0.00490$ and uncomplexed ligand = 0.4824

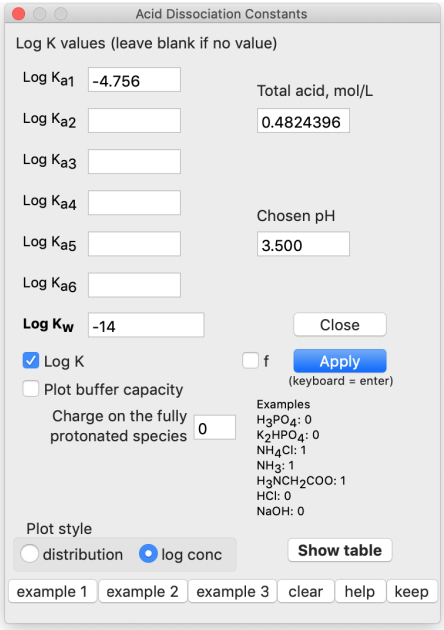
Solve for alpha fractions and find $\alpha_0 \frac{[L]}{\alpha_1} = [CH_3COOH] = 0.457$.

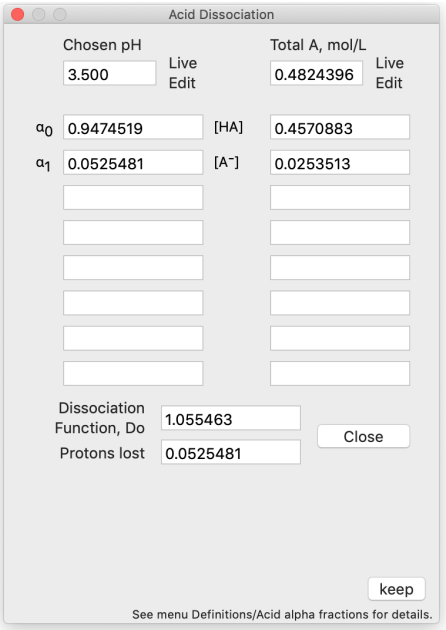




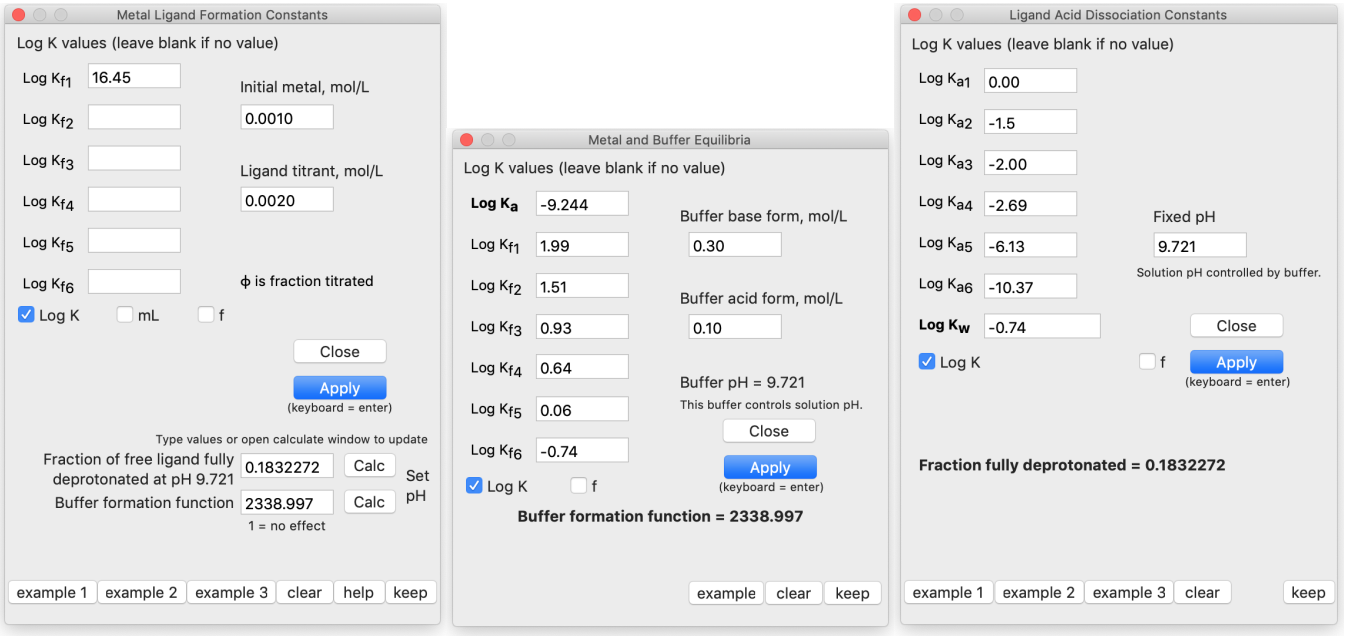


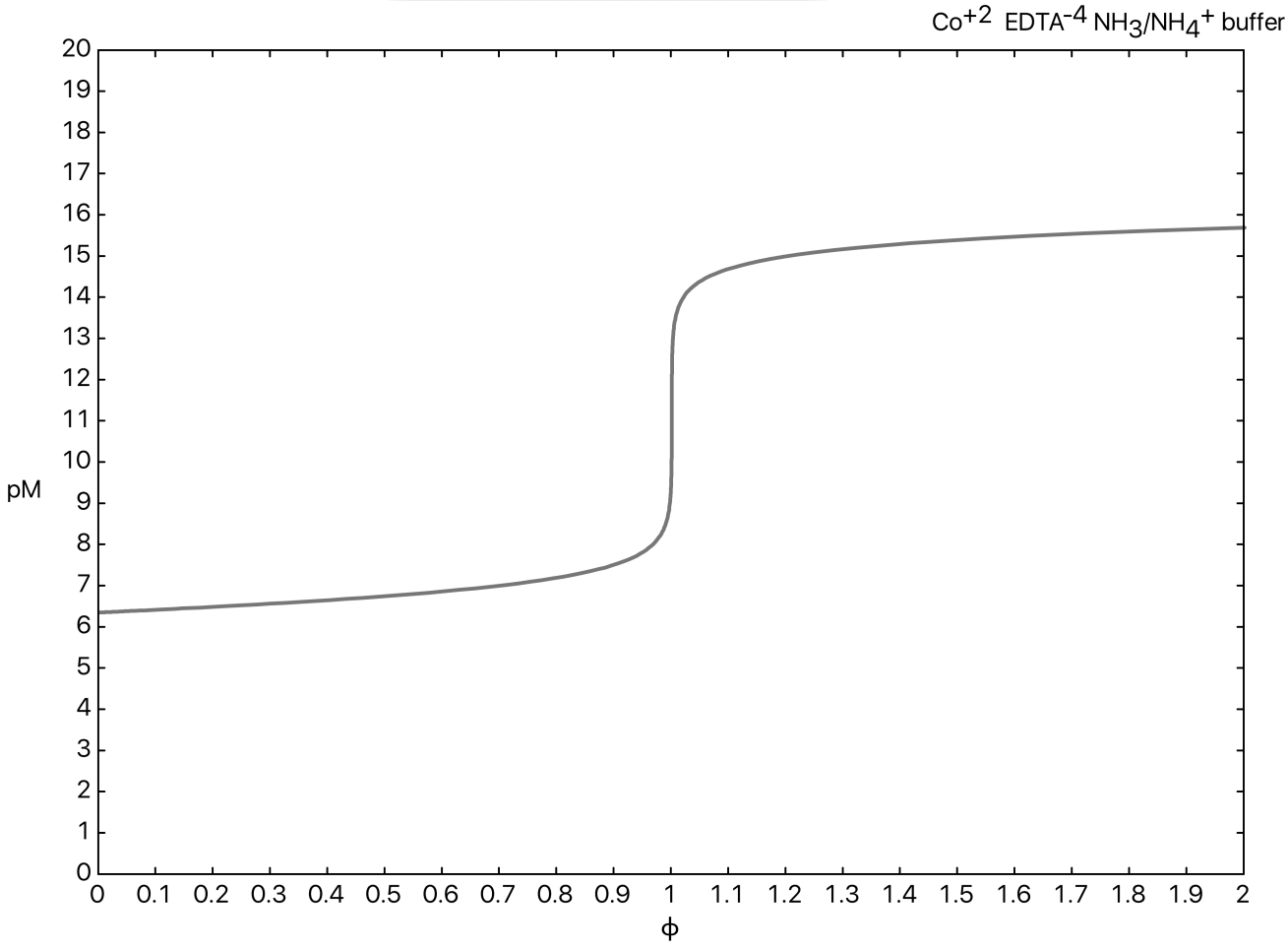






H. *Plot pMetal titration*. The 0.30 M NH_3 and 0.10 M NH_4Cl will act as a buffer to determine the pH. Click the **second Calc button**. Based on the K_a for NH_4^+ and the buffer concentrations the pH is 9.721. The NH_3 will also act as a ligand so enter the Co^{+2} NH_3 K_f values. The buffer formation function of ammonia with Co^{+2} is 2339. Click the **first Calc button**. The fraction of EDTA fully deprotonated at pH 9.721 depends on the K_a values for H_4EDTA^{+2} and is 0.183.





Note: it is a helpful to use Option/Title to label your graphs.