1) (20 points) Consider the titration curves for 25.00 mL of 0.1000 M malonic acid with 0.1000 M NaOH. For malonic acid, $K_{a1} = 1.42 \times 10^{-3}$ and $K_{a2} = 2.01 \times 10^{-6}$

   a) Calculate the pH before any base is added

   b) Find the pH when 37.50 mL of base is added.
2) (15 points) Calculate the Zn\(^{2+}\) concentration and pZn at the equivalence point of the titration of 25.00 mL of 0.02 M Zn(NO\(_3\))\(_2\) with 0.02 M EDTA at pH 10. For EDTA, \(\alpha_4 = 0.35\) at pH 10, and for ZnY, \(K_f = 3.2 \times 10^{16}\).

3) (20 points) The following expression describes the hydronium ion concentration in a solution of an acid salt.

\[
[H_3O^+] = \frac{K_{a2}c_{NaHA} + K_w}{1 + c_{NaHA} / K_{al}}
\]

a) List two assumptions that can be made to simplify this expression.

b) Write the simplified expression for the hydronium concentration.
c) Using the full expression from b), calculate the hydronium concentration of a 0.100 M solution of NaHtar, where H$_2$tar is diprotic tartaric acid with $K_{a1} = 9.20 \times 10^{-4}$ and $K_{a2} = 4.31 \times 10^{-5}$. Also calculate the pH.

d) Now use the simplified expression to calculate the hydronium ion concentration and the pH. Are the results the same? Explain.
4) (12 points) Consider the following titration curves, and match the descriptions of the titrations with the proper curve.

A mixture of bases with strong acid.
A mixture of acids with strong base.
A weak acid with strong base.
A strong acid with strong base.
Ammonia with HNO₃.
Sodium carbonate with HCl.

5) (13 points) Sketch an $\alpha$ plot for the maleic acid, which has $K_{a1} = 1.3 \times 10^{-2}$ and $K_{a2} = 5.9 \times 10^{-7}$. Label all important curves and points, etc. on the plot.
6) (20 points) Define, explain, or otherwise describe the following:

   a) $\alpha_1$ (for a diprotic acid)

   b) zwitterion

   c) ligand

   d) $\beta_2$ for a complex ML$_2$
e) conditional constant