1. We have introduced a term “the Defining Reaction”. What is meant by this term in this course? The minor reaction which is dominant in determining what the final solution characterization will be. (For A/B systems, characterization = final pH)

2. In dealing with a polyprotic acid, we have introduced three specific terms. Given a generic polyprotic acid, H₄X (pK₁ = 2.0, pK₂ = 2.8, pK₃ = 3.8, pK₄ = 4.8)
   a) What is the Parent Acid? H₄X
   b) What is the Salt? X⁻⁴
   c) What is/are the Intermediate Salts? H₃X⁻, H₂X²⁻, HX³⁻
   d) Construct a pH line for H₄X, placing all known information on the line.

   ![pH line diagram]

   e) At what pH value would H₂X²⁻ be the only species present in bulk amount in the solution? Show how you get to your answer.

   From pH line, H₂X²⁻ is the only species present at pH = 3.3

3. Calculate the pH of the following systems. The use of the pH line is suggested.
   a) 50.00 mL of 0.28 M Benzoic Acid, HOBz (MW = 122.0, Kₐ = 6.3 x 10⁻⁵), to which is added 75.00 mL of 0.12 M Sodium Hydroxide, NaOH (MW = 40.00)

   ![Before and After reaction diagram]

   Before rxn: 14 mmol
   After rxn: 5 mmol

   pH = 4.20 + log⁶ 9 / 5 > [4.46]
b) 50.00 mL of 0.28 M Benzoic Acid, HOBz (MW = 122.0, \( K_a = 6.3 \times 10^{-5} \)), to which is added 100.00 mL of 0.14 M Ammonia, NH\(_3\) (MW = 17.00, \( K_b = 1.8 \times 10^{-5} \)).

\[
\begin{align*}
\text{HOBz} & \quad 14 \text{ mmol} \\
\text{NH}_3 & \quad 14 \text{ mmol} \\
\end{align*}
\]

Both NH\(_3\) + HOBz are limiting reagents — you are at \textit{midpoint}.

4. You are given a sample weighing 1.2500 g to be analyzed for the presence of Sodium Carbonate (MW = 106.0; for Carbonic Acid, H\(_2\)CO\(_3\), MW = 62.00, \( pK_1 = 6.37, pK_2 = 10.25 \)). You have available a standardized solution of HCl (MW = 36.50) whose value is 0.1189 M. You need 15.52 mL of this HCl titrant to reach a phenolphthalein end point when you titrate the sample.

\[
\begin{align*}
\text{H}_2\text{CO}_3 & \quad 6.37 \text{ mmol} \\
\text{HCO}_3^- & \quad 8.31 \text{ mmol} \\
\text{CO}_3^{2-} & \quad 10.25 \text{ mmol} \\
\end{align*}
\]

You start at \( \text{CO}_3^{2-} \) and end at \( \text{HCO}_3^- \) b/c titration would take place in 2 separate stages.

At endpoint, 1.845 mmol H\(_3\)O\(^+\) added, so 1.845 mmol of \( \text{CO}_3^{2-} \) will be converted to \( \text{HCO}_3^- \).

\[
\begin{align*}
\text{Na}_2\text{CO}_3 & \quad 106.0 \text{ mg} \\
\text{Na}_2\text{CO}_3 & \quad 1 \text{ mmole} \\
\end{align*}
\]

\[
\text{Na}_2\text{CO}_3 = \frac{106.0 \text{ mg} \times 1.845 \text{ mmole}}{1 \text{ mmole}} = 15.65 \%
\]

**BONUS QUESTION:** (1 pt) These kind of samples often contain Sodium Bicarbonate (NaHCO\(_3\), MW = 84.00) as well as Sodium Carbonate, Na\(_2\)CO\(_3\) (MW = 106.00). Suppose you were asked to determine whether or not your sample had any Sodium Bicarbonate in it (but NO numerical value). What piece of evidence would you need which would allow you to answer this question WITHOUT HAVING TO DO ANY CALCULATIONS AT ALL! Explain your reasoning.

If it took 15.52 mL to titrate the \( \text{CO}_3^{2-} \) to \( \text{HCO}_3^- \), it will take another 15.52 mL to convert these mmoles to \( \text{H}_2\text{CO}_3 \).

If MORE THAN 15.52 mL is needed to complete the titration, the additional amount over 15.52 mL represents the mmoles of \( \text{HCO}_3^- \) that were originally present. So, if 2nd titration takes > 15.52 mL, some \( \text{HCO}_3^- \) was originally present in sample.

Pledge: I have neither given nor received any unacknowledged aid on this quiz.