

Homework week 9

- You are going to titrate 50 mL of 2×10^{-3} F propanoic acid ($\text{CH}_3\text{CH}_2\text{COOH}$; $K_a = 1.34 \times 10^{-5}$) with 3.00×10^{-3} M NaOH.
 - How many mL are needed to reach the equivalence point?
 - What is the pH at the equivalence point?
- 1.0 L aqueous solution containing 0.001 moles of the very soluble Na_2HPO_4 is prepared.
 - Write the mass balance expression for the phosphate in this system. ... and for the sodium.
 - Write the charge balance expression for this solution.
 - What is the approximate pH of this solution?
- What is the pH of a 2×10^{-8} F HNO_3 solution? (3 sig figs, please)
- Sketch the titration curve (pH vs mL base added) for the titration of 50 mL of 1.0×10^{-3} F H_3PO_4 with 1.0×10^{-2} F NaOH. (Key pH values that you should include are start of titration, each inflection point, buffer regions and 2.0 mL past the second equivalence point, i.e., 2 mL past the point where HPO_4^{2-} was the dominant species) ($\text{p}K_{a1}=2.15$; $\text{p}K_{a2}=7.20$; $\text{p}K_{a3}=12.35$) (Note: The strength of PO_4^{3-} as a base combined with the concentrations used, cause the 3rd e.p. to be “sloppy” and accurate pH values more difficult to calculate. Remember: In a titration, we assume that the neutralization reaction “goes to completion”, i.e., K is very large for the neutralization reaction. Using K_{b1} for PO_4^{3-} and assume an initial concentration of PO_4^{3-} and HPO_4^{2-} of 5×10^{-4} M (... what appears to be a buffer): See if the 1:1 ratio of these species holds – as it should for a buffer – once you let it go to equilibrium.)
 - Write the primary neutralization reactions occurring along the curve.
- A buffer is prepared at pH 10.0 using NaHS and Na_2S . 50.0 mL of this solution is titrated using 3.00×10^{-3} F NaOH and the equivalence point is reached after 8.60 mL. What is $[\text{S}^{2-}]$ in the original buffer? (for H_2S : $\text{p}K_{a1}=7.02$; $\text{p}K_{a2}=13.89$)
- Sketch the fractional distribution diagram for H_2S . (α vs pH)
- Lake Travis is around a pH of 8.2. With the limestone in the area, the primary acid/base system logically involves carbonates. (BTW... What is the basic chemical composition of limestone??) (For carbonic acid, H_2CO_3 : $\text{p}K_{a1}= 6.13$ $\text{p}K_{a2}= 9.91$.) Explain to me whether you feel this is a stable, nicely buffered system for this lake... and why or why not.
 - At this pH, what is the $[\text{HCO}_3^-]:[\text{CO}_3^{2-}]$ ratio?
 - A bit of a tougher question... Since limestone is minimally soluble in water, but dissolves in acid; where did the acid come from to dissolve the limestone? (Note: In case you’re thinking “pollution”: Pristine spring waters in the area that have minimal pollution show similar pHs.)
 - OK... feeling pretty good? Let’s continue to explore our local lake. Back in the lab, analysis determined that the total carbonate content ($[\text{H}_2\text{CO}_3]+[\text{HCO}_3^-]+[\text{CO}_3^{2-}]$) was 5.33×10^{-4} M. Can you tell me $[\text{CO}_3^{2-}]$.. AND $[\text{Ca}^{2+}]$ in Lake Travis?

==== Spoiler alert: Don’t look below until you tried the above on your own =====

Hints for selected problems:

- 2b) Remember $[A^{2-}]$ represents concentration of the species A^{2-} and $2[A^{2-}]$ represents the “concentration of negative charges” that it possesses.
3. Is the value you determined “reasonable”, i.e., about what you’d intuitively expect?
5. What is the reaction taking place when you add the OH^- ? i.e., at the e.p, which species have you determined the concentration of?
7. a) What is the criteria of a “good buffer”?
b) At this point, we’re only looking for the ratio.
c) Carbonated soft drinks taste tangy because of the acid present.
d) What is the dominant species? (conversely, what species is/are negligible at this pH?) Can you make any simplifying assumption? Regarding the $[Ca^{2+}]$... need to know K_{sp} for $CaCO_3$ to solve.