# CHAPTER 8
## CONSEQUENCES OF EQUILIBRIUM

**CHAPTER OUTLINE**

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**HW:** "Text" and Supplementary problems at bottom.
"Text" Problems

T8.11 Calculate the Molar concentrations of H⁺ ions and the pH of the following solutions:
(a) 25.0 cm³ of 0.144 M HCl(aq) was added to 25.0 cm³ of 0.125 M NaOH(aq)
(b) 25.0 cm³ of 0.15 M HCl(aq) was added to 35.0 cm³ of 0.15 M KOH(aq)
(c) 21.2 cm³ of 0.22 M HNO₃(aq) was added to 10.0 cm³ of 0.30 M NaOH(aq)

T8.12 Determine whether aqueous solutions of the following salts have a pH equal to greater than, or less than 7; if pH > 7 or pH < 7, write a chemical equation to justify your answer.
(a) NH₄Br
(b) Na₂CO₃
(c) KF
(d) KBr

T8.13 (a) A sample of potassium acetate, KCH₃CO₂ (M = 98.15), of mass 8.4 g is used to prepare 250 cm³ of solution. What is the pH of the solution?
(b) What is the pH of a solution when 3.75 g of ammonium bromide, NH₄Br (M = 97.9), is used to make 100 cm³ of solution?

T8.14 A solution of equal concentrations of lactic acid and sodium lactate was found to have pH = 3.08.
(a) What are the values of pKₐ and Kₐ of lactic acid?
(b) What would the pH be if the acid had twice the concentration of the salt?

T8.25 The amino acid, tyrosine, has pKₐ for deprotonation of its carboxylic acid group? What are the relative concentrations of tyrosine and its conjugate base at a pH of:
(a) 7.0
(b) 2.2
(c) 1.5

Supplementary Home Work Problems

S8.1 The acid dissociation constant of lactic acid is Kₐ = 8.4 x 10⁻⁴. Calculate the pH of the following solutions.
(a) 200 mL of 0.10 M lactic acid.
(b) 200 mL of 2.0 M sodium lactate
(c) 200 mL of 0.10 M lactic acid following the addition of 0.005 mol of NaOH.
S8.2 The base equilibrium constant of aniline \([C_6H_5NH_2]\) is \(K_b = 4.3 \times 10^{-10}\). Calculate the pH of the following solutions.
(a) 400 mL of 0.05 M aniline
(b) 400 mL of 0.10 M anilinium chloride \([C_6H_5NH_3^+Cl^-]\).
(c) 400 mL of 0.05 M aniline following the addition of 0.015 mol of HCl

S8.3 One initially has a solution containing 500 mL of 0.40 M benzoic acid \([K_a = 6.5 \times 10^{-5}]\). How many mL of 1.0 M NaOH are required to reach half-way to the equivalence point (stoichiometric point)? What is the pH of the solution at this point?

S8.4 The acid dissociation constant of formic acid \([HCOOH]\) is \(K_a = 1.8 \times 10^{-4}\). A solution is prepared with an initial concentration \([HCOOH] = 0.5\) M. Sufficient KOH is added to the solution to raise the pH to 4.25. What are the concentrations, \([HCOOH]\) and \([HCOO^-]\) of the solution at this pH?

S8.5 Alanine is an amino acid with \(R = -CH_3\). Its pKa’s are pKa’(\(\alpha\)-COOH)=2.35 and pKa”(\(\alpha\)-NH\(_3^+\))=9.69.
   a) At what pH is the ratio \([\text{Ala}^+]/[\text{Ala}]=0.25\)?
   b) What is the ratio \([\text{Ala}^+]/[\text{Ala}]\) at \(pH=10.5\)?

S8.6 Lysine is an amino acid with \(R = -(CH_2)_4NH_2\). Its pKa’s are pKa’(\(\alpha\)-COOH)=2.18, pKa”(\(\alpha\)-NH\(_3^+\))=8.95 and pKa’’’(\(\epsilon\)-NH\(_3^+\))=10.53.

The structure of the fully protonated form is:

\[
\begin{array}{c}
\text{H} \\
\text{C} \\
\text{CO}_2\text{H}
\end{array}
\]

\[
\begin{array}{c}
\text{H}_3\text{N} \quad \begin{array}{c}
\text{C} \\
\text{CO}_2\text{H}
\end{array} \\
\text{(CH}_2\text{)}_4 \\
\text{NH}_3^+
\end{array}
\]

a) What is the pH and average charge after the addition of 0.5 equiv. of NaOH to the protonated form.
b) What is the pH and average charge after the addition of 1.0 equiv. of NaOH to the protonated form?
c) What is the isoelectric point, pI?
d) How many equiv. of NaOH must be added to the protonated form to reach pH=10.53?
e) Draw the structure of lysine after the addition of 2.0 equiv. of NaOH to the protonated form.
f) Draw the structure of lysine at pH = 5.57.
The solubility product (aka solubility constant) of MgF₂ is $K_s = 6.4 \times 10^{-9}$.

(a) Calculate the solubility of MgF₂ in pure water.
(b) Calculate the solubility of MgF₂ in 0.1 M MgCl₂(aq).
(c) Calculate the solubility of MgF₂ in 0.2 M KF(aq).