PART 1

1&2. Which one of the following acids is NOT a strong acid?

(a) HF    (b) HCl    (c) HClO₃    (d) HNO₃    (e) HClO₄

3&4. A 0.10 M solution of which one of the following salts has a pH less than 7?

(a) KClO₄    (b) CH₃NH₃Cl    (c) Ba(NO₂)₂    (d) NaF    (e) KCN

5&6. Which of the following combinations are buffer solutions? All components are present in 0.10 M concentrations.

(1) HCN and NaCN    (2) HNO₃ and NH₄NO₃    (3) NH₃ and NH₄Cl    (4) HClO₃ and NaClO₃

(a) 1, 3, 4    (b) 1, 2    (c) 2, 3, 4    (d) 3, 4    (e) 1, 3
7&8. Consider 0.1 M solutions of the following weak acids:

\[
\begin{align*}
\text{CH}_3\text{COOH} & \quad K_a = 1.8 \times 10^{-5} \\
\text{HCN} & \quad K_a = 4.0 \times 10^{-10}
\end{align*}
\]

Which of the following statements is NOT correct?

(a) Acetic acid is a stronger acid than hydrocyanic acid.
(b) \([\text{CN}^-]\) in HCN solution > \([\text{CH}_3\text{COO}^-]\) in CH$_3$COOH solution.
(c) The concentration of OH$^-$ ions is greater in the HCN solution.
(d) The pH of the CH$_3$COOH solution is lower than the pH of the HCN solution.
(e) [H$^+$] in CH$_3$COOH solution > [H$^+$] in HCN solution.

9&10. The conjugate base of NH$_3$ is:

(a) OH$^-$  (b) H$_3$O$^+$  (c) NH$_4^+$  (d) NH$_2^-$  (e) none of these

11&12. The acid-base indicator, HIn, has a $K_a$ value of $1.0 \times 10^{-4}$. The endpoint for any titration using this indicator will occur at pH = ____:

(a) 7  (b) 13  (c) 8  (d) 10  (e) 4

13&14. If $K_w$ is $9.6 \times 10^{-14}$ at 60$^\circ$C, what is the pH of pure water at 60$^\circ$C?

(a) 6.51  (b) 7.00  (c) 7.11  (d) 7.45  (e) none of these
15&16. What is the pH of a $1.5 \times 10^{-4}$ M KOH?
   (a) 2.95  (b) 3.80  (c) 10.18  (d) 10.79  (e) 11.52

17&18. A 0.50 M solution of a monoprotic acid is 4.1% ionized. What is the $K_a$ for this weak acid?
   (a) $1.3 \times 10^{-3}$  (b) $3.7 \times 10^{-4}$  (c) $1.2 \times 10^{-6}$  (d) $1.8 \times 10^{-7}$  (e) $8.4 \times 10^{-4}$

19&20. Calculate the $\Delta G^\circ$ for the reaction at 25°C if the value of the thermodynamic equilibrium constant, $K_{thermo}$, is 0.145? ($R = 8.314 \text{ J/mol·K}$)
   (a) +4.78 kJ/mol  (b) −4.78 kJ/mol  (c) +75.2 kJ/mol
   (d) +400. kJ/mol  (e) −75.2 kJ/mol
21&22. What is the pH of a solution that is 0.10 M KCN?

(a) 11.20 (b) 10.01 (c) 7.00 (d) 3.45 (e) 2.67

23&24. It is desired to buffer a solution at pH = 3.80.
What molar ratio of HNO₂/NO₂⁻ should be used?

(a) 1.2/1 (b) 0.80/1 (c) 0.12/1 (d) 0.35/1 (e) 2.8/1
The following 5 questions (25 – 31) deal with a single titration:

25&26. A 100.0 mL sample of 0.200 $M$ methylamine is titrated with 0.100 $M$ HCl. Calculate the initial pH before the titration is begun. The $K_b$ for methylamine is on the back of the envelope.

(a) 11.45  (b) 12.00  (c) 12.25  (d) 12.59  (e) 13.00

27&28. A 100.0 mL sample of 0.200 $M$ methylamine is titrated with 0.100 $M$ HCl. Calculate the pH after 135 mL of 0.100 $M$ HCl has been added.

(a) 10.12  (b) 9.53  (c) 10.38  (d) 8.63  (e) 10.70
(5 pts) 29. A 100.0 mL sample of 0.200 \( M \) methylamine is titrated with 0.100 \( M \) HCl. Calculate the pH at the equivalence point.

(5 pts) 30. A 100.0 mL sample of 0.200 \( M \) methylamine is titrated with 0.100 \( M \) HCl. Calculate the pH after 235 mL of 0.100 \( M \) HCl is added.
(5 pts) **31.** A 100.0 mL sample of 0.200 M methylamine is titrated with 0.100 M HCl. Using the answers to Questions 21-26, sketch the titration curve with pH on the vertical axis and milliliters of acid added on the horizontal axis. Label the axes and plot your 4 points. Point out the buffer region and the equivalence point. If you cannot complete the calculations, sketch what the curve should look like for partial credit.

(5 pts) **32.** A solution is prepared by mixing 2.00 mol of NaCH₃COO and 3.00 mol of CH₃COOH in a 1.00 liter container. To 200. mL of this solution is added 130. mL of 1.00 M NaOH. What is the pH of this new solution?
33. (a) All solutions of soluble salts and bases will become saturated if the concentrations are high enough. Write the appropriate equilibrium and the $K_{sp}$ expression for $\text{ZnF}_2(s)$.

(b) If 16.2 grams of $\text{ZnF}_2$ will dissolve in 1.00 L of solution at 20°C, what is the $K_{sp}$ for $\text{ZnF}_2$ at 20°C?