1. Write the equilibrium expressions for each of the following reactions:

   a. $HF_{(aq)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + F^-_{(aq)}$

   b. $CH_3COO^-_{(aq)} + H_2O_{(l)} \leftrightarrow CH_3COOH_{(aq)} + OH^-_{(aq)}$

   c. $HNO_2_{(aq)} + H_2O_{(l)} \leftrightarrow H_3O^+_{(aq)} + NO_2^-_{(aq)}$

2. For the following reaction

   $CH_3COOH_{(aq)} + H_2O_{(l)} \leftrightarrow CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$

   (a) Determine the equilibrium concentration of $CH_3COOH$ if $K_a$ for the reaction is $5.6 \times 10^{-10}$. The initial concentration of $CH_3COOH$ is 0.10 M.

   (b) How much hydronium ion is present in this reaction at equilibrium?
(c) What is the pH of this solution?

(d) What happens to the equilibrium if we add more hydronium ion to the mixture? (Think about Le Chatelier's Principle.) What is present in the equilibrium mixture?

3. Consider the reaction:

\[
\text{CH}_3\text{COO}^- (aq) + \text{H}_2\text{O}(l) \leftrightarrow \text{CH}_3\text{COOH}(aq) + \text{OH}^- (aq) \quad K_b = 5.6 \times 10^{-10}
\]

What happens when a strong base is added to this solution?

- More CH₃COO⁻ is formed
- More CH₃COOH is formed
- No change occurs

4. Calculate the pH of the following:

(a) a 0.054 M KOH solution.

(b) a 0.172 M aqueous solution of the weak acid H₂PO₄⁻ \( K_a = 6.2 \times 10^{-8} \)

Questions 3 and 4 come directly from a previous final exam.