Due: Wednesday, 8-March-2006 by class time. Please remember that this is to be your own work.

1a) Calculate the pH of a buffered solution that is 0.100 \( M \) in \( \text{C}_6\text{H}_5\text{COOH} \) (benzoic acid, \( K_a = 6.4 \times 10^{-5} \)) and 0.100 \( M \) in \( \text{C}_6\text{H}_5\text{CO}_2\text{Na} \).

b) Calculate the pH after 20.00\% (by moles) of the benzoic acid is converted to benzoate ion by addition of base. Use the dissociation equilibrium

\[
\text{C}_6\text{H}_5\text{CO}_2\text{H}^{(aq)} \leftrightarrow \text{C}_6\text{H}_5\text{CO}_2^- (aq) + \text{H}^+ (aq)
\]

to calculate the pH.

c) Do the same as in part (b), but use the following equilibrium to calculate the pH:

\[
\text{C}_6\text{H}_5\text{CO}_2^- (aq) + \text{H}_2\text{O} (l) \leftrightarrow \text{C}_6\text{H}_5\text{CO}_2\text{H}^{(aq)} + \text{OH}^- (aq)
\]

d) Do your answers in parts (b) and (c) agree? Explain.

2) When carbon dioxide dissolves in water, it undergoes a multistep equilibrium process, with \( K_{overall} = 4.5 \times 10^{-7} \), which is simplified to the following:

\[
\text{CO}_2(g) + \text{H}_2\text{O} (l) \leftrightarrow \text{H}_2\text{CO}_3(aq) \\
\text{H}_2\text{CO}_3(aq) + \text{H}_2\text{O} (l) \leftrightarrow \text{HCO}_3^- (aq) + \text{H}_3\text{O}^+ (aq)
\]

a) What is the pH of non-polluted rainwater in equilibrium with clean air? \( P_{\text{CO}_2} \) in clean air = 3.2 \( \times 10^{-4} \) atm, and Henry’s Law Constant for \( \text{CO}_2 \) at 25°C is 0.033 mol/L•atm.

b) What is the \([\text{CO}_3^{2-}]\) in rainwater? \( K_a \) for \( \text{HCO}_3^- = 4.7 \times 10^{-11} \).

c) If the partial pressure of \( \text{CO}_2 \) triples in the next few decades, what will the pH of rainwater become?

3) Hydrogen peroxide, \( \text{H}_2\text{O}_2 \) (\( pK_a = 11.75 \)), is commonly used as a bleaching agent and an antiseptic. The product sold in drugstores is 3\% \( \text{H}_2\text{O}_2 \) by mass and contains 0.001\% \( \text{H}_3\text{PO}_4 \) by mass to stabilize the solution. Which contributes more \( \text{H}_3\text{O}^+ \) to the solution, the \( \text{H}_2\text{O}_2 \) or the \( \text{H}_3\text{PO}_4 \)? Demonstrate your answers by the appropriate calculations.

4) A chemist needs a buffer with \( \text{pH} = 4.15 \) How many milliliters of pure formic acid (density = 1.220 g/mL) must be added to 355 mL of 0.0578 \( M \) \( \text{NaOH} \) solution to obtain such a buffer?
5) Can a solution have $[\text{H}_3\text{O}^+] = 3 \times [\text{OH}^-]$? Can a solution have $\text{pH} = 3 \times \text{pOH}$? If so, will the two solutions be the same?