**AP Free Response Practice #3** (2017 #3, shortened, 5 points)

3. Nitrogen monoxide, NO(g), can undergo further reactions to produce acids such as $HNO_2$, a weak acid with a $K_a$ of $4.0 \times 10^{-4}$ and a $pK_a$ of 3.40.

   a. A student is asked to make a buffer solution with a pH of 3.40 by using 0.100 M $HNO_2$(aq) and 0.100 M NaOH(aq).

      i. Explain why the addition of 0.100 M NaOH(aq) to 0.100 M $HNO_2$(aq) can result in the formation of a buffer solution. Include the net ionic equation for the reaction that occurs when the student adds the NaOH(aq) to the $HNO_2$(aq). (2 points)

      ii. Determine the volume, in mL, of 0.100 M NaOH(aq) the student should add to 100. mL of 0.100 M $HNO_2$(aq). to make a buffer solution with a pH of 3.40. Justify your answer. (2 points)

   b. A second student makes a buffer by dissolving 0.100 mol of $NaNO_2$(s) in 0.100 M $HNO_2$(aq). Which is more resistant to changes in pH when a strong acid or a strong base is added, the buffer made by the second student or the buffer made by the first student in part (c)? Justify your answer. (1 point)

a.) (i) Adding NaOH to $HNO_2$, neutralizing some of the acid to create $NO_2^-$. As long as moles of added NaOH are less the the initial moles of $HNO_2$, after the neutralization the mixture will contain both a weak acid, $HNO_2$, and its conjugate base, $NO_2^-$, which is a buffer solution.

$HNO_{2(aq)} + OH^-_{(aq)} \rightarrow NO_2^-{}_{(aq)} + H_2O_{(l)}$

(ii) Since the $pK_a(HNO_2) = 3.40$, when $[HNO_2] = [NO_2^-]$ the pH of the buffer sol'n will be 3.40 ($pH = pK_a$). Thus, half of the $HNO_2$ needs to be converted to conjugate base: the student should add 50.0 mL of 0.100 M NaOH.

b.) The buffer made by the second student will be more resistant to changes in pH b/c it contains a higher concentration of $HNO_2$ and $NO_2^-$ to react with added $H^+$ or $OH^-$.