Buffer/Titration/K_a Challenge Problem

An unknown student in an unknown city in an unknown school titrates an unknown amount of weak acid dissolved in an unknown amount of water with a strong base of unknown concentration. After adding 20.00 mL of strong base, the pH is 5.00. The student continues the titration, reaching the equivalence point after 26.00 mL base is added. What is K_a for the acid? *[Hint: determine A^-/HA when pH = 5.00.]*

The titration is 20/26 complete when pH = 5.00. That means that 20 parts of HA of 26 have been converted to A^- and 6 parts out of 26 remain as HA. You can then use this to determine K_a from either the K_a expression or from HH. The total volume is unimportant because it will cancel out in either method.

$$K_a = \frac{[H^+][A^-]}{[HA]} = \frac{[H^+]\left(\frac{20}{V}\right)}{\frac{6}{V}}; [H^+] = 10^{-5.00} = 1.0\times10^{-5}\ \text{M}$$

$$\text{Thus, } K_a = \frac{\left(1.0\times10^{-5}\right)\left(20\right)}{6} = 3.3\times10^{-5}$$

From HH:

$$5.00 = pK_a + \log\frac{[A^-]}{[HA]} = pK_a + \log\left(\frac{20}{6}\right) = pK_a + 0.52;\ pK_a = 5.00 - 0.52 = 4.48$$

$$K_a = 10^{-pK_a} = 10^{-4.48} = 3.3\times10^{-5}$$