

More Stuff about Aqueous Equilibrium: CH 17, Part 4

3/20/19 ①

Demo: Strong Acid + Strong Base

0.1 M HCl

50 mL

0.1 M NaOH

predicted equivalence point of 50 mL
pH = 7

Titration: Weak Acid + Strong Base

- 50 mL 0.1 M acetic acid ($pK_a = 4.75$) is titrated with 0.1 M NaOH. Calculate pH initial, after 20 mL, after 50 mL
- Initial pH is determined by the weak acid
- Use K_a to solve for pH

Weak Acid + Strong base

0.1 M acetic acid

50 mL initial pH = 2.87

After 20 mL NaOH added

$$\text{Initial moles HA} = 0.050 \text{ L} \cdot 0.1 \frac{\text{mol}}{\text{L}} = 0.005 \text{ mol}$$

$$\text{moles OH}^- \text{ added} = 0.020 \text{ L} \cdot 0.1 \frac{\text{mol}}{\text{L}} = 0.002 \text{ mol}$$



$$\text{moles A}^- = \text{moles OH}^- \text{ added} = 0.002 \text{ mol}$$

$$\begin{aligned} \text{equilibrium moles HA} &= \text{HA moles initial} - \text{mol OH}^- \text{ added} \\ &= 0.003 \text{ mol} \end{aligned}$$

$$\begin{aligned} \text{pH} &= \text{p}K_a + \log \frac{[\text{A}^-]}{[\text{HA}]} = \text{p}K_a + \log \frac{\text{A}^- \text{ mol}}{\text{HA mol}} = 4.75 + \log \left(\frac{0.002}{0.003} \right) \\ &= 4.56 \end{aligned}$$

50 mL NaOH

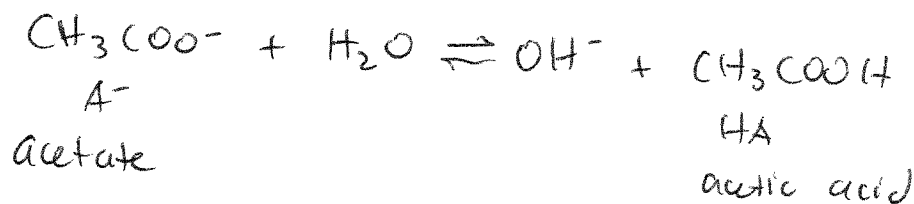
(2)

Initial moles HA = ~~0.005 mol~~ ^{0.005 mol}

$$0.050 \text{ L} \times \frac{0.1 \text{ mol}}{\text{L}} = 0.005 \text{ mol } \text{OH}^- = \text{mol } \text{A}^-$$

$$\text{equilibrium moles HA} = \underset{\text{initial HA}}{0.005 \text{ mol}} - \underset{\text{OH}^-}{0.005 \text{ mol}} = \underset{\text{HA}}{0 \text{ mol}}$$

$$\frac{0.005 \text{ mol } \text{A}^-}{0.1 \text{ L}} = 0.050 \text{ M } \text{A}^-$$



$$pK_b + pK_a = pK_w$$

$$pK_b = 14 - 4.75$$

$$pK_b = 9.25$$

$$K_b \cdot K_a = K_w$$

$$K_b = 5.6 \times 10^{-10}$$

	CH_3COO^-	OH^-	CH_3COOH
I	0.05 M	0	0
C	-x	x	x
E	0.05-x	x	x

Weak Acid vs. Strong Acid Titration Curves

$$\frac{x^2}{0.05} = 5.6 \times 10^{-10}$$

$$x = 5.3 \times 10^{-6}$$

$$pOH = 5.28$$

$$pH = 8.72$$

① A soln. of WA has a higher initial pH than a SA at the same concentration

② pH at the midpoint = pK_a

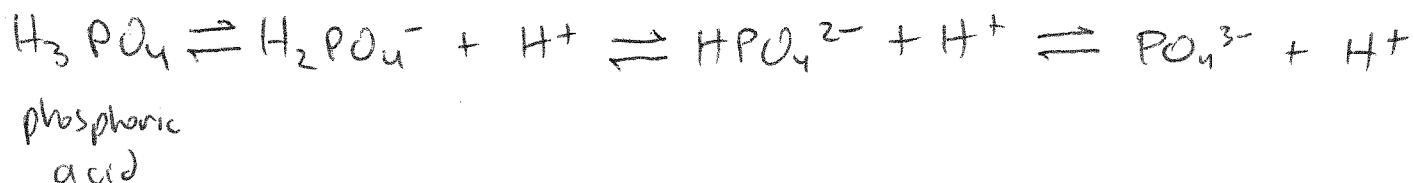
③ At the equivalence point $pH > 7.0$ for a weak acid but $pH = 7.0$ for strong acid

Titration of Weak Base with Strong Acid

- Titration curve looks similar to a WA being titrated by SB, but it is "flipped over"
- pH during the titration:
 - high pH initially
 - $\text{pH} < 7$ at equivalence point (only BH^+ present)
 - low pH at end

Titration of Polyprotic Acids

- Each H^+ dissociation has an equivalence point
- The pH at the midpoint of each dissociation occurs at the pK_a for that step



Clicker question:

100 mL of 0.1 M malonic acid is titrated with 0.1 M NaOH.
At what point in the titration is true?

Use of Indicators

- Indicators are weak acids that have a different color than their conjugate base form
- Each indicator has a pK_a at which it changes colors
- An indicator can be used to find the equivalence point in a titration as long as the end point (where it changes color) is on the steep part of the titration curve!