More Stuff about Aqueous Equilibria

A buffer is made by adding 0.300 mol CH_3COO and 0.300 mol $NaCH_3COO$ to enough water to make 1.00 L of sln. calculate pH before and after 0.020 mol of NaOH is added. pk_a acetic acid = 4.75

Before: $pH = pka + \frac{\log [A^-]}{[HA]}$

$pH = pka + \log(1) = 4.75$

After: Assume that all added OH^- reacts w/ HA to produce A^-.

	$[CH_3COOH]$	$[OH^-]$	$[CH_3COO^-]$
I	0.300	0.200	0.300
C	−0.020	−0.020	+0.020
E	0.280	0	0.320

Use Henderson-Hasselbalch equation

The ratio of molarity can be calculated using a ratio of moles

$pH = pka + \log(n_{A^-}/n_{HA})$

$pH = 4.78 + \log(0.320/0.280) = 4.80$

pH went up a little bit

Titration

- The titrant (acid/base of known concentration) is added to analyte (a base/acid unknown concentration)
- An indicator (or pH meter) is used to determine when the sln. has reached the equivalence point, where moles acid = moles base

Titration of SA w/ SB

50 mL 0.100 M HCl titrated w/ 0.100 mol NaOH. pH during titration?

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O$$

H^+ Cl^- Na^+ OH^-

Cl^- and Na^+: spectator ions

$$H^+(aq) + OH^-(aq) \rightarrow H_2O$$

assume complete reaction for SA w/ SB

Initial (No NaOH added):

$0.1 \frac{mol}{L}$ HCl $\Rightarrow$ $0.1 \frac{mol}{L}$ H^+

$$pH = -\log H^+ = 1$$

After (NaOH added):

$$\frac{0.1 \text{ mol } H^+}{L} \times 0.050 L = 0.005 \text{ mol } H^+$$

$$\frac{0.1 \text{ mol } OH^-}{L} \times 0.01 L = 0.001 \text{ mol } OH^-$$

$$\text{mol } H^+_{eq} = \text{mol } H^+_{initial} - \text{mol } OH^-_{added}$$

$$[H^+] = \frac{0.004 \text{ mol } H^+}{0.060 L} = 0.067 M$$

$$pH = -\log(0.067)$$

$$= 1.18$$

$$[H^+] = \frac{0.0025 \text{ mol}}{0.075 L} = 0.033 M$$

$$pH = -\log(0.033) = 1.48$$

Total (25 mL NaOH)

$$\text{mol } H^+_{eq} = 0.005 \text{ mol} - \underbrace{(0.1 \frac{mol}{L} \times 0.025 L)}_{0.0025 \text{ mol}} = 0.0025 \text{ mol } H^+$$

50 mL of NaOH added

the equivalence point!

mol H^+ initial = mol NaOH added

For SA-SB pH = 7

100 mL of NaOH added

$$\text{mol } OH^-_{eq} = \text{mol } OH^-_{added} - \text{mol } H^+_{initial}$$

$$= \left(0.1 \frac{\text{mol}}{\text{L}} \times 0.1 \text{ L}\right) - 0.005 \text{ mol} = 0.005 \text{ mol } OH^-$$

$$[OH^-] = \frac{0.05 \text{ mol}}{0.15 \text{ L}} = 0.033 \text{ M}$$

$$pOH = 1.5 \quad pH = 12.5$$

- Initially, the pH goes up slowly
  - $[H^+]$ is calculated by subtracting the moles of OH^- added from the initial moles of H^+ and dividing by the total volume
  - Just before the equivalence point, the pH rises rapidly
  - At the equivalence point, pH = 7
  - After the equivalence point, the pH goes up rapidly but then levels off
  - $[OH^-]$ is calculated by subtracting the initial moles of H^+ from the moles of OH^- added and
- Titration curve looks similar to the strong acid being titrated by strong base, but it's flipped over

- pH during titration: high pH initially, pH = 7 at equivalence point, low pH at end

Titration WA + SB

50 mL of 0.1M acetic acid titrated w/ 0.1 M NaOH

Initially, $HA_{(aq)} \rightleftharpoons H^+_{(aq)} + A^-_{(aq)}$

$0.1M - x \quad x \quad x$

- Initially, only HA is present

$$K_a = \frac{x^2}{0.1-x} = 1.8 \times 10^{-5}$$

assume $\frac{x^2}{0.1} = 1.0 \times 10^{-5}$

$x = 1.34 \cdot 10^{-3}$ $[H^+]$

$pH = 2.87$

After 20 mL NaOH

$OH^-_{(aq)} + HA_{(aq)} \rightarrow A^-_{(aq)} + H_2O$

- Up to equivalence point, both HA and A^- are present (buffer region)
- After the equivalence point, only A^- is present