Acid-Base Titrations

I. Strong Acid Titration

$$H^+ + OH^- \rightleftharpoons H_2O \qquad K_t = \frac{1}{K_w} \gg 1$$

100.0 mL of 0.100 M HCl titrated with x mL of 0.100 M NaOH

Vary x from 0 to 200 mL; measure pH.

Prof. Rob Corn
Chem M3LC

Acid-Base Titrations: I. Strong Acid Titration

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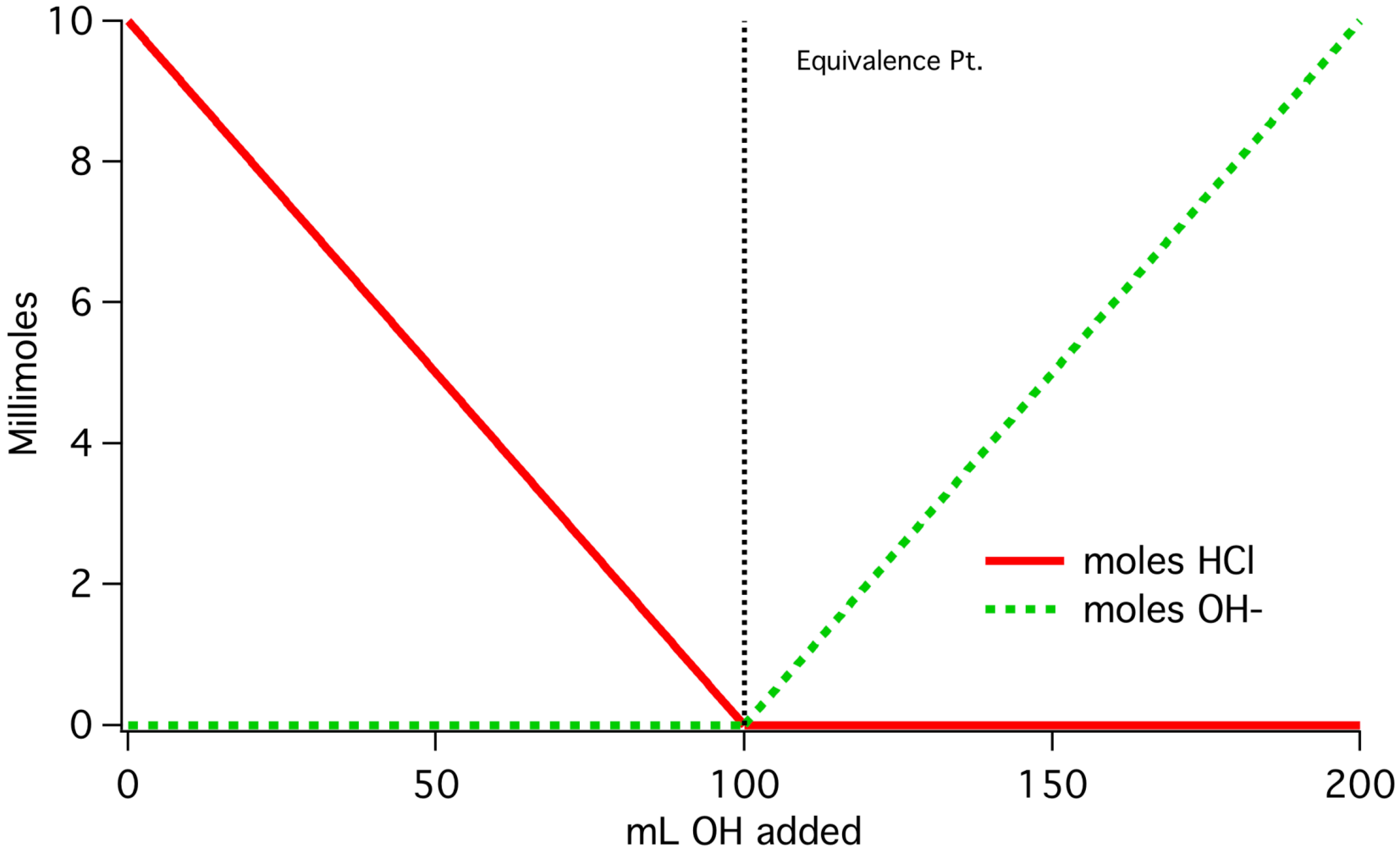

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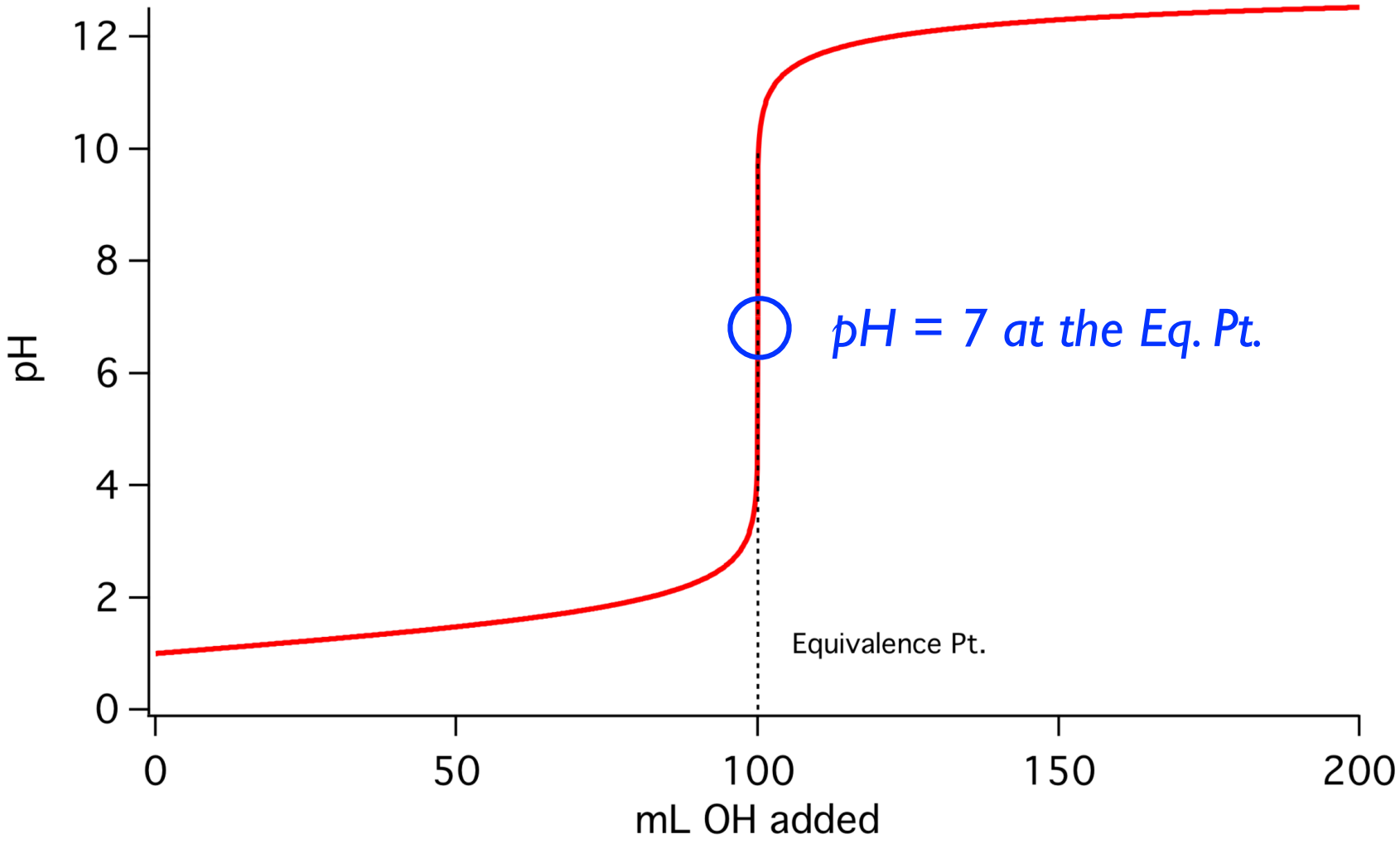


Acid-Base Titrations

II. Weak Acid Titration

$$HA + OH^- \rightleftharpoons A^- + H_2O \qquad K_t = \frac{K_a}{K_w} \gg 1$$

Example:

Titrate 100.0 mL of 0.100M HA with x mL of 0.100M NaOH

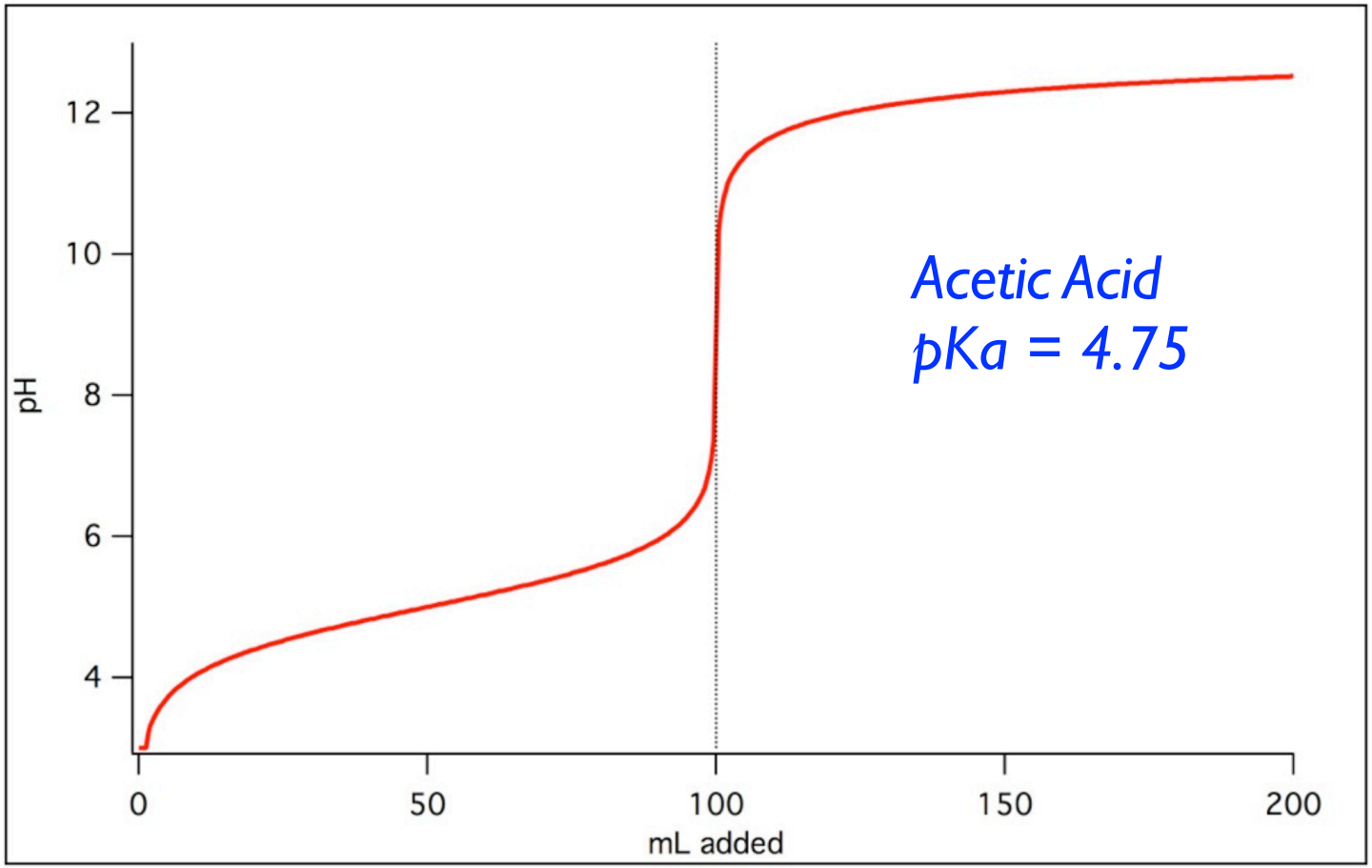
HA - Acetic Acid pKa = 4.75

Acid-Base Titrations: II. Weak Acid Titration

$$HA + OH^- \rightleftharpoons A^- + H_2O \qquad K_t = \frac{K_a}{K_w} \gg 1$$

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Calculate the pH of solution at x = 0.0, 50.0, 100.0 and 150.0 mL

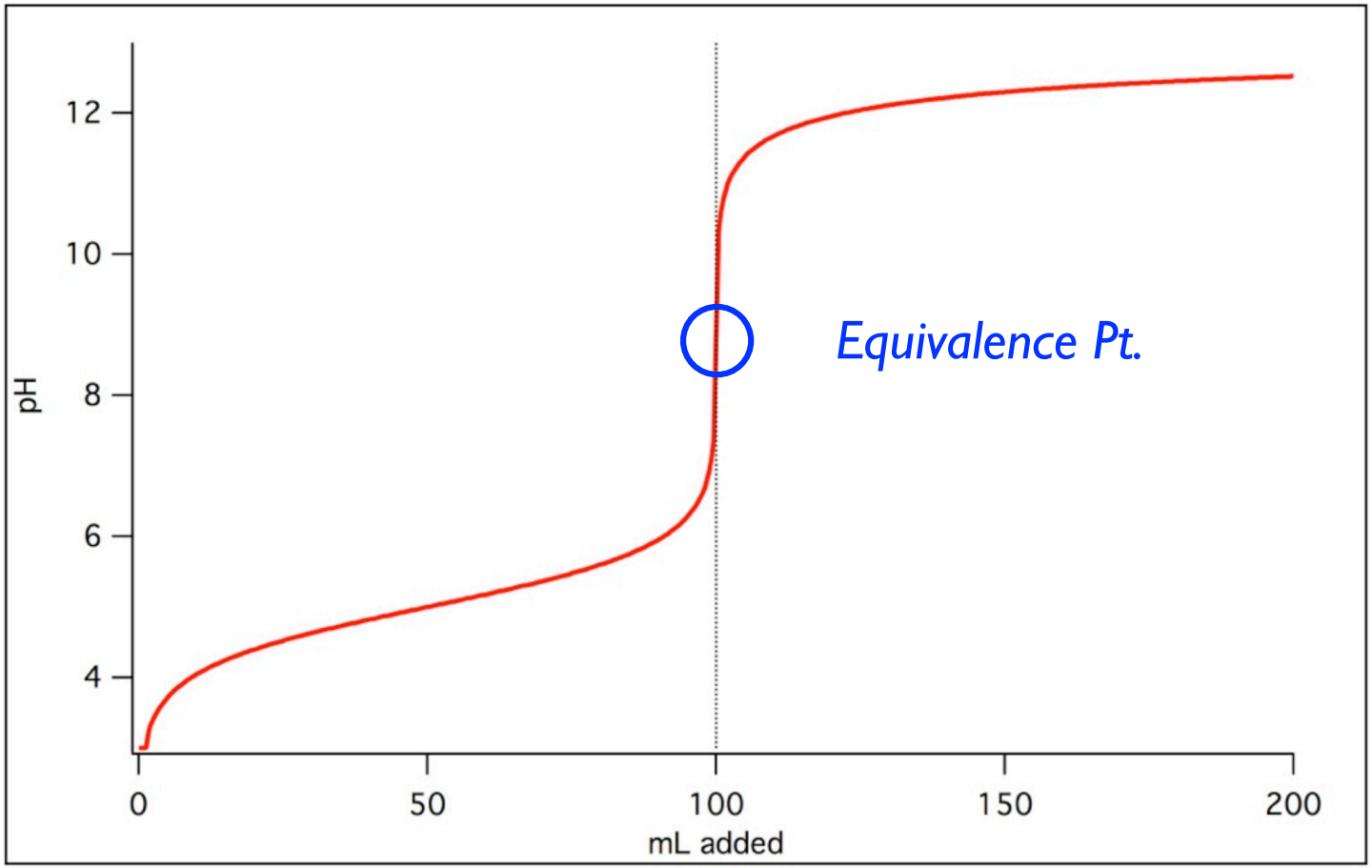


Acid-Base Titrations: II. Weak Acid Titration

$$HA + OH^- \rightleftharpoons A^- + H_2O \qquad K_t = \frac{K_a}{K_w} \gg 1$$

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

x = 100.0 mL



Acid-Base Titrations: II. Weak Acid Titration

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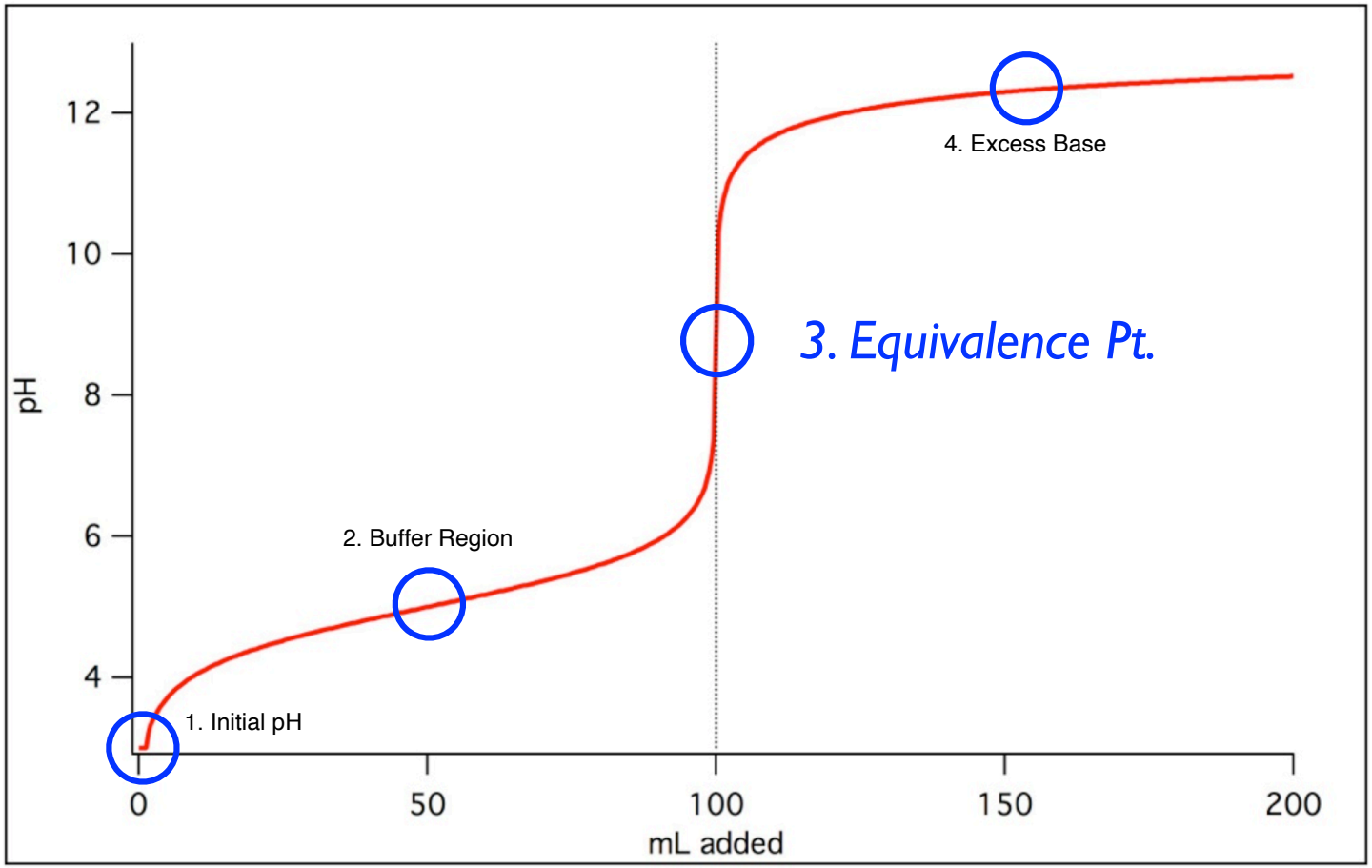

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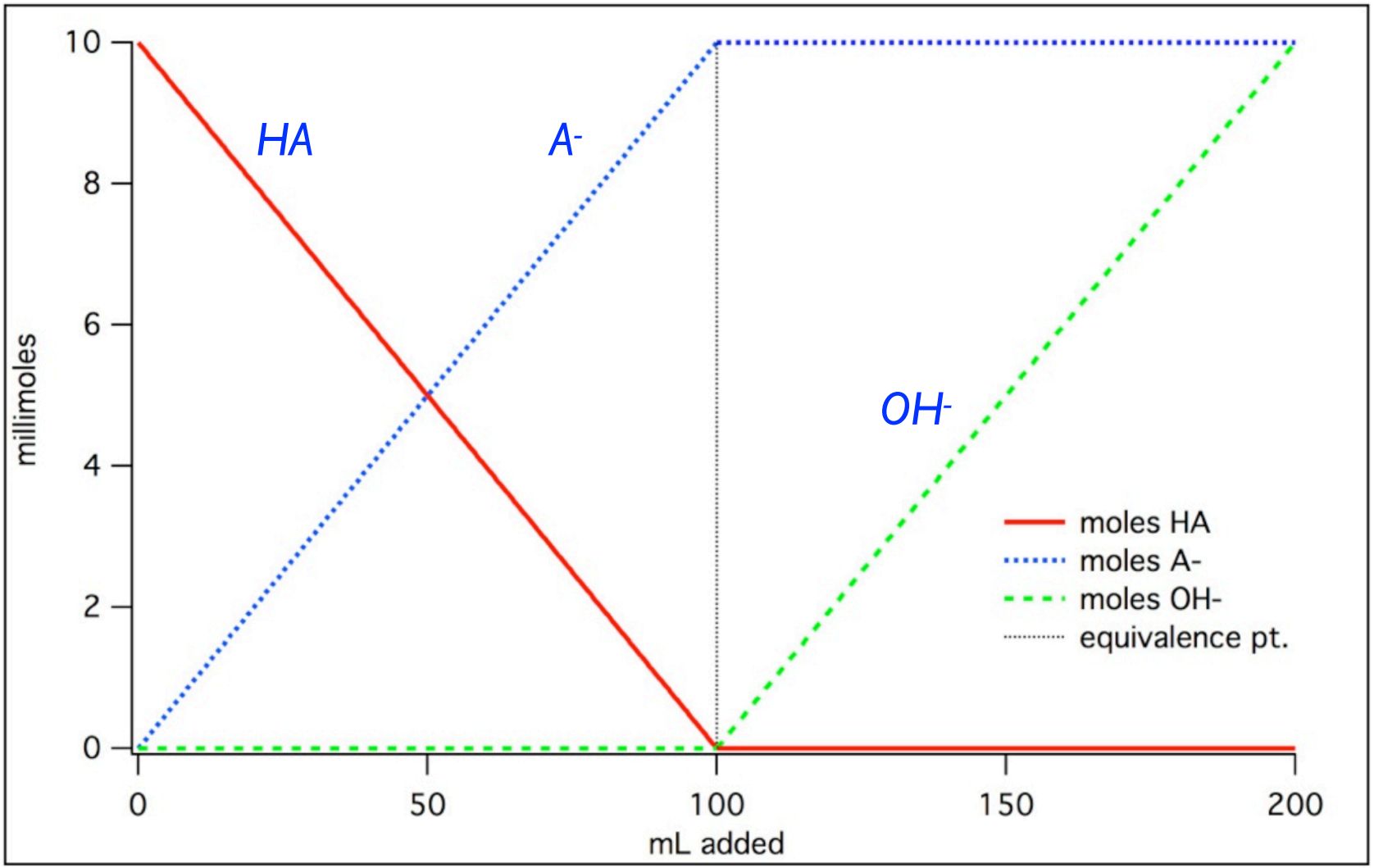

Acid-Base Titrations: II. Weak Acid Titration

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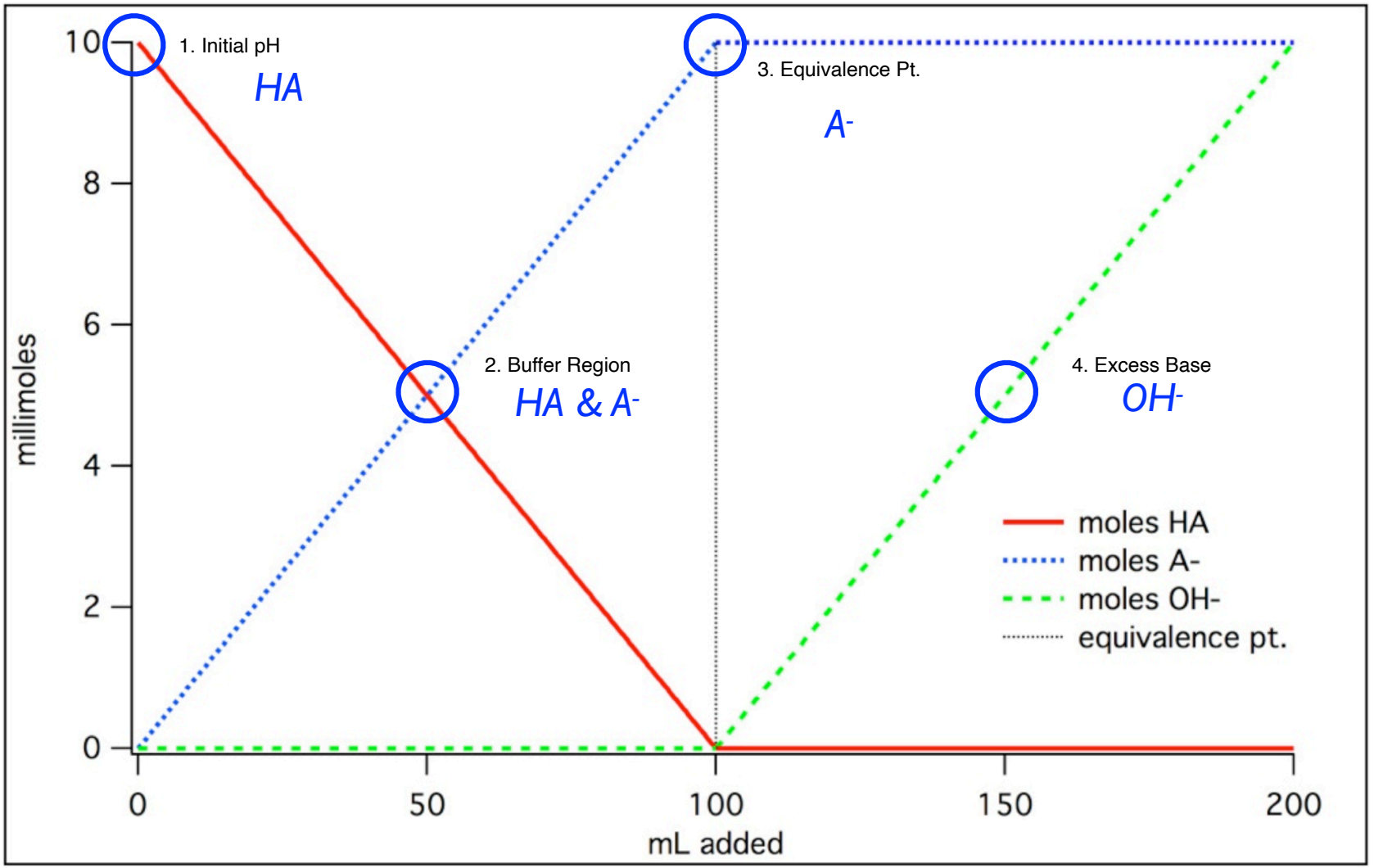
100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH



II. Weak Acid Titration

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Calculate the pH of the solution at points:

x = 0.0 mL	*Initial pH: HA*	
x = 50.0 mL	*Buffer Region: HA & A^-*	*Major Species Present in Graph*
x = 100.0 mL	*Equivalence Point: A^-*	
x = 150.0 mL	*Excess Base OH^-*	

II. Weak Acid Titration

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Calculate the pH of the solution at points:

x = 0.0 mL *Initial pH: HA*

We calculate the pH here for a 100 mL solution of the weak acid HA with concentration C^{tot}

$$[H^+] = \sqrt{K_a C_{HA}^{tot}}$$

$$C_{HA}^{tot} = \frac{m_{HA}}{V_{init}}$$

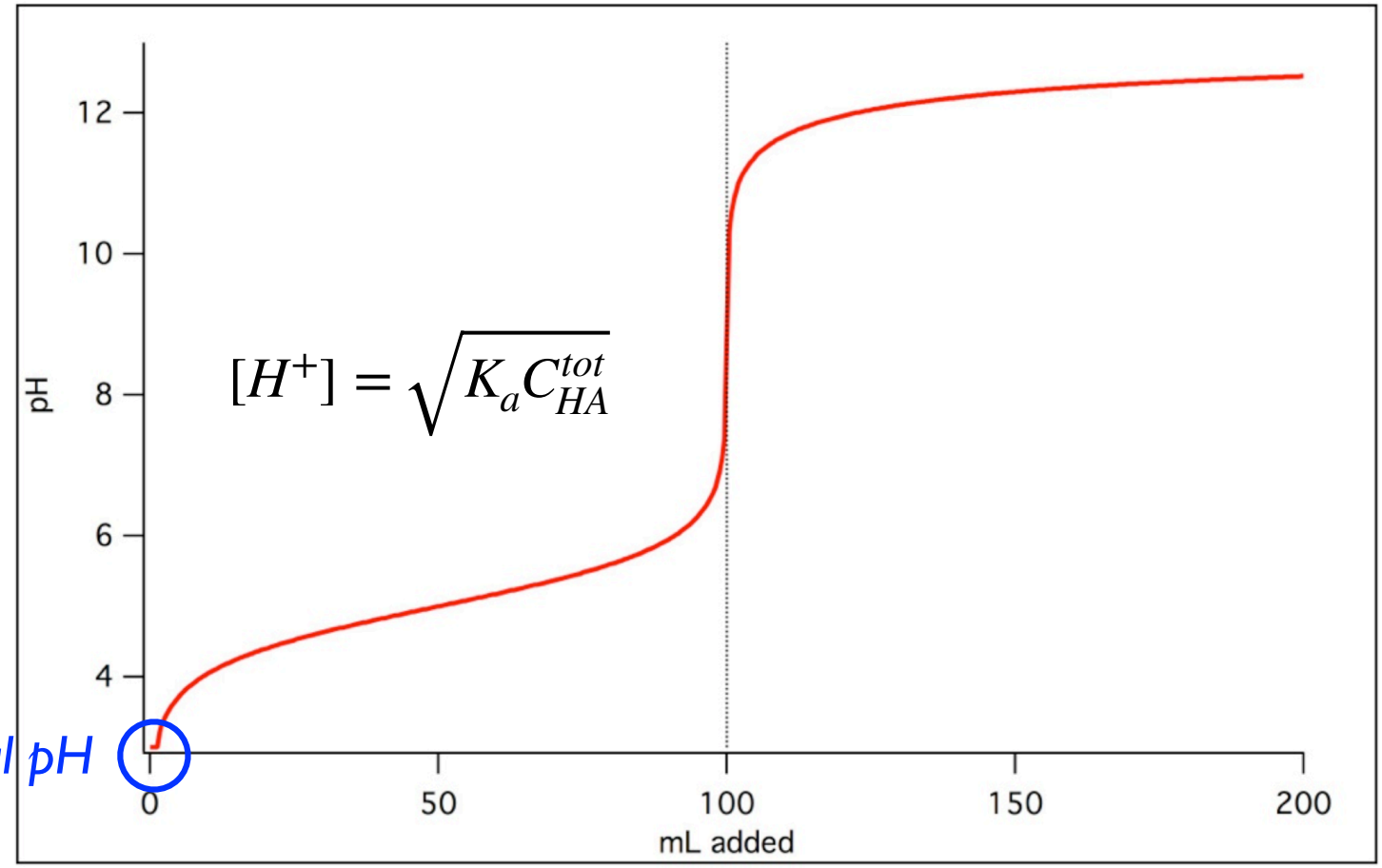
See the AC05a Handout on pH Calculations for this Equation!

Acid-Base Titrations: II. Weak Acid Titration

$$HA + OH^- \rightleftharpoons A^- + H_2O \qquad K_t = \frac{K_a}{K_w} \gg 1$$

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Initial pH. x = 0 mL V_{tot} *= 100 mL*



Initial pH

II. Weak Acid Titration

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Calculate the pH of the solution at points:

x = 0.0 mL Initial Weak Acid pH: HA

x = 50.0 mL Buffer Region: HA & A^-

We calculate the pH here using the "H-H equation":

$$[H^+] = K_a \frac{[HA]}{[A^-]} = K_a \frac{m_{HA}}{m_{A^-}}$$

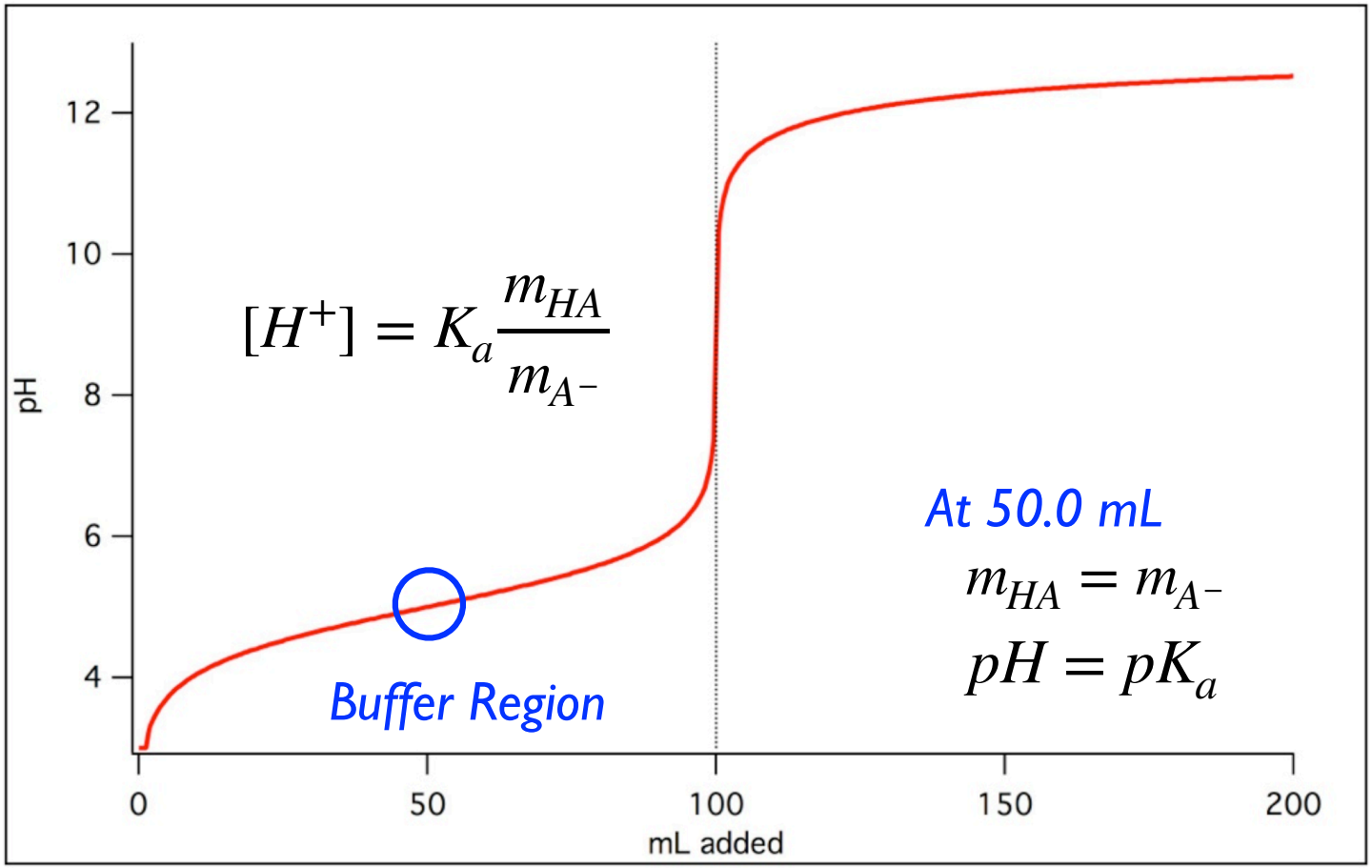
At 50.0 mL , $m_{HA} = m_{A^-}$ and $pH = pK_a$

Acid-Base Titrations: II. Weak Acid Titration

$$HA + OH^- \rightleftharpoons A^- + H_2O \qquad K_t = \frac{K_a}{K_w} \gg 1$$

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Buffer Region. x = 50 mL V_{tot} *= 150 mL*



II. Weak Acid Titration

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Calculate the pH of the solution at points:

x = 0.0 mL — Initial Weak Acid pH: HA

x = 50.0 mL — Buffer Region: HA & A^-

x = 100.0 mL — Equivalence Point: A^-

We calculate the pH here for a 200 mL solution of the weak acid salt A^- with "C^{tot}"

$$[OH^-] = \sqrt{K_b C^{tot}_{A^-}}$$

$$C^{tot}_{A^-} = \frac{m_{A^-}}{V_{tot}}$$

See the AC05a Handout on pH Calculations for this Equation!

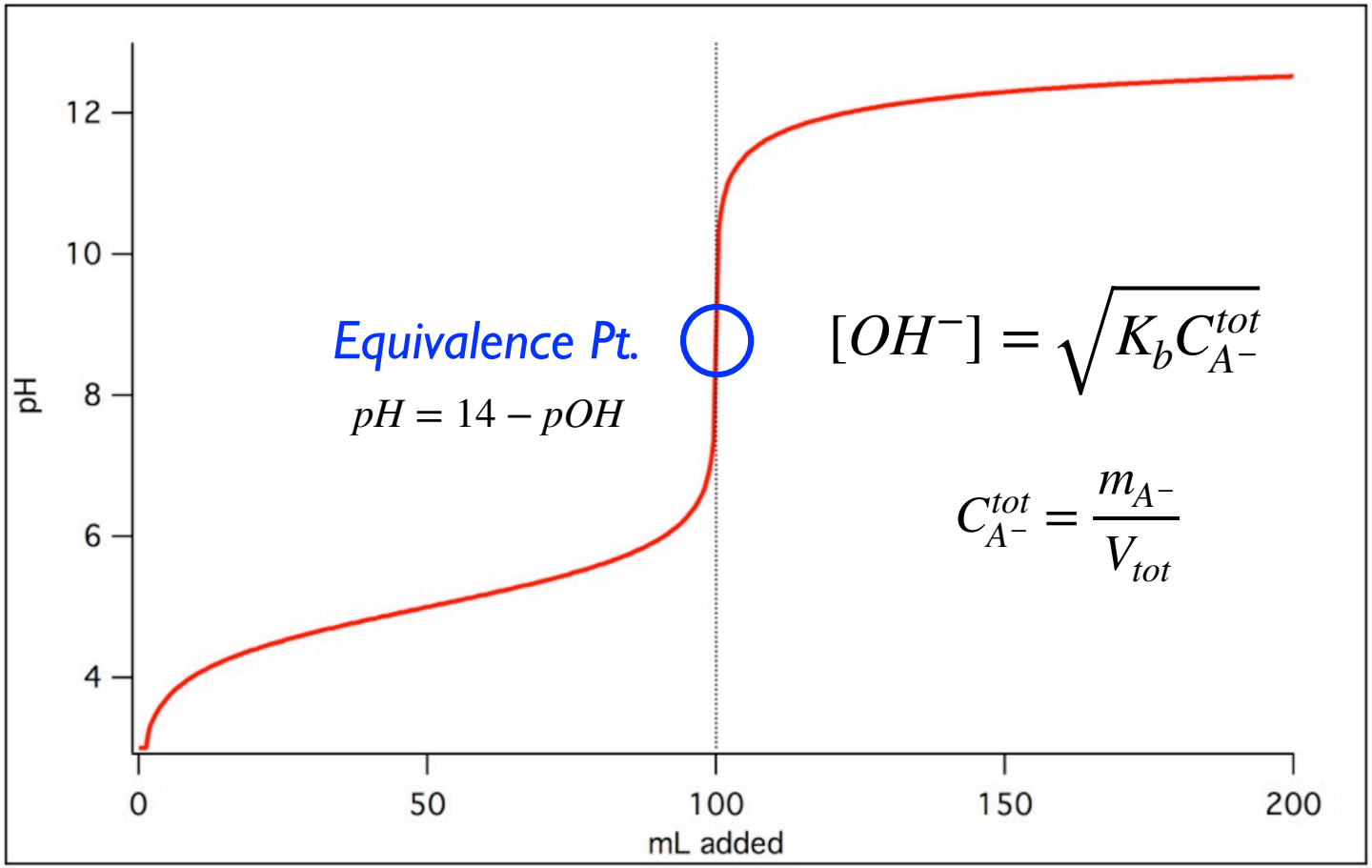
$$pH = 14 - pOH$$

Acid-Base Titrations: II. Weak Acid Titration

$$HA + OH^- \rightleftharpoons A^- + H_2O \qquad K_t = \frac{K_a}{K_w} \gg 1$$

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Equivalence Pt. x = 100 mL V_{tot} *= 200 mL*



II. Weak Acid Titration

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Calculate the pH of the solution at points:

x = 0.0 mL Initial Weak Acid pH: HA

x = 50.0 mL Buffer Region: HA & A^-

x = 100.0 mL Equivalence Point: A^-

x = 150.0 mL Excess Base OH^-

We calculate the pH here using the moles of the excess 50 mL of OH^- solution

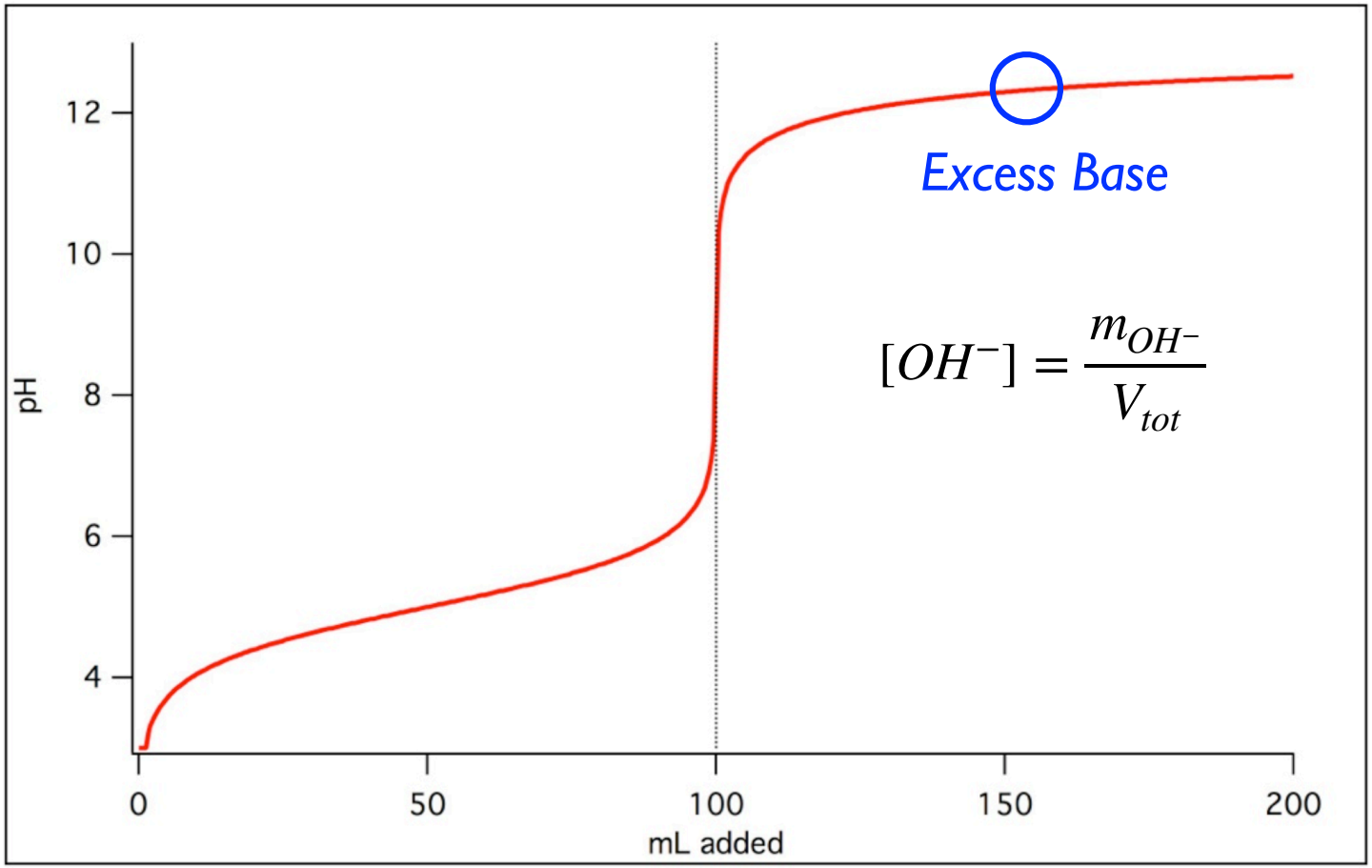
$$[OH^-] = \frac{m_{OH^-}}{V_{tot}}$$

Acid-Base Titrations: II. Weak Acid Titration

$$HA + OH^- \rightleftharpoons A^- + H_2O \qquad K_t = \frac{K_a}{K_w} \gg 1$$

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Excess Base. x = 150 mL V_{tot} *= 250 mL*



Acid-Base Titrations: II. Weak Acid Titration — Summary

$$HA \rightleftharpoons H^+ + A^-$$

$$pK_a = 4.75 \qquad K_a = \frac{[H^+][A^-]}{[HA]} \qquad K_a = 10^{-4.75}$$

x = 0.0 mL — Initial Weak Acid pH: HA

$$[H^+] = \sqrt{K_a C_{HA}^{tot}} \qquad C_{HA}^{tot} = \frac{m_{HA}}{V_{init}}$$

x = 50.0 mL — Buffer Region: HA & A-

$$[H^+] = K_a \frac{[HA]}{[A^-]} = K_a \frac{m_{HA}}{m_{A^-}}$$

x = 100.0 mL — Equivalence Point: A-

$$[OH^-] = \sqrt{K_b C_{A^-}^{tot}} \qquad C_{A^-}^{tot} = \frac{m_{A^-}}{V_{tot}}$$

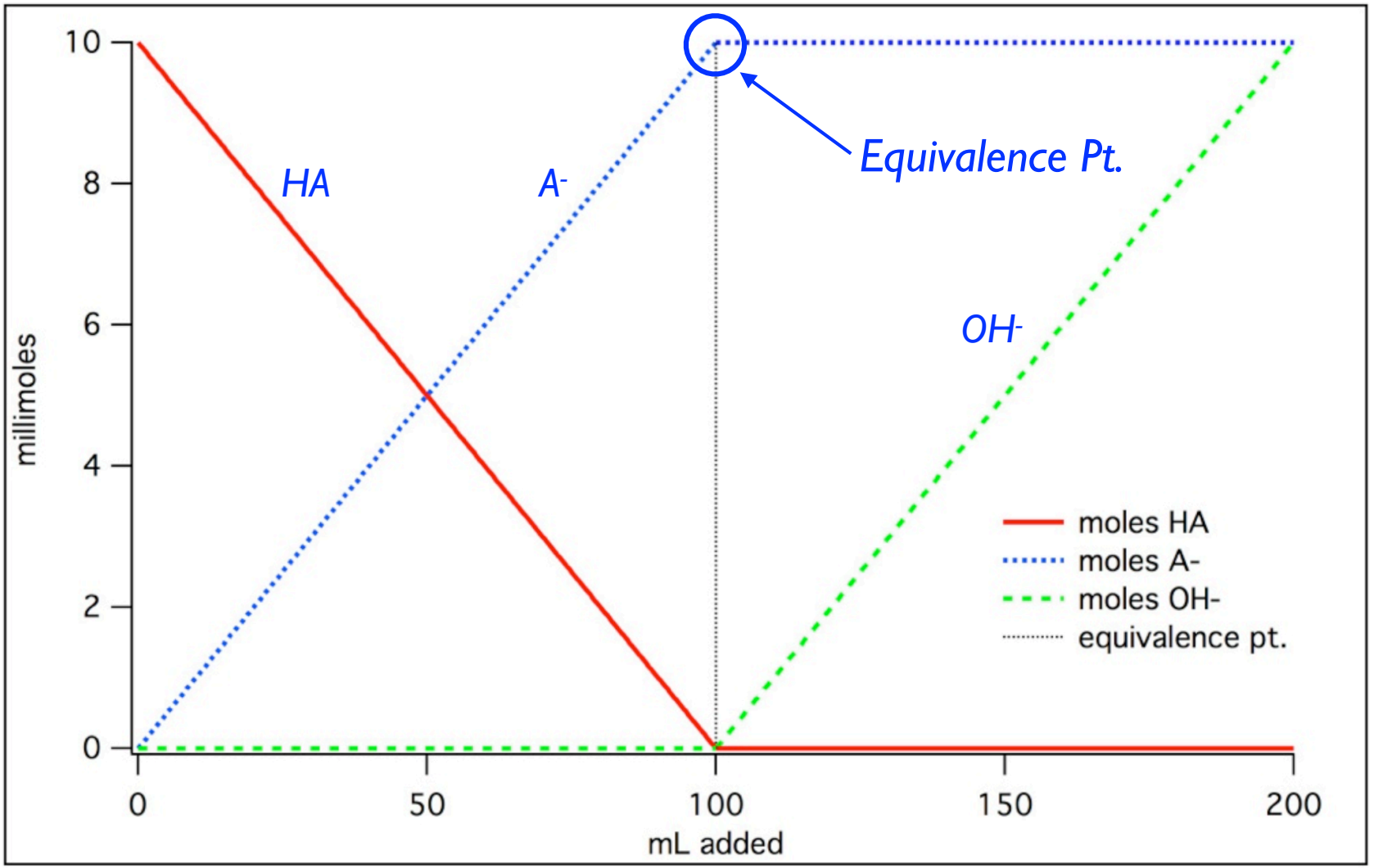
x = 150.0 mL — Excess Base OH-

$$[OH^-] = \frac{m_{OH^-}}{V_{tot}}$$

Acid-Base Titrations: II. Weak Acid Titration

$$HA + OH^- \rightleftharpoons A^- + H_2O \qquad K_t = \frac{K_a}{K_w} \gg 1$$

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH



Acid-Base Titrations: Weak Acid Titration Equivalence Point

$$HA + OH^- \rightleftharpoons A^- + H_2O \qquad K_t = \frac{K_a}{K_w} \gg 1$$

100.0 mL of 0.100M HA titrated with x mL of 0.100M NaOH

Equivalence Point: x = 100 mL. V_{tot} *= 200 mL*