CONCEPT: POLYPROTIC ACID TITRATIONS PT.1

Equivalence Volume (V_e)

The titration of 50.0 mL of 0.100 M H_3PO_4 with 0.100 M NaOH

Before any Strong Base is added

The titration of 50.0 mL of 0.100 M H_3PO_4 with 0.00 mL of 0.100 M NaOH

	H_3PO_4 +	H_2O $\rightleftharpoons$	$H_2PO_4^-$ +	H_3O^+
Initial	**0.100 M**	✕	**0.000 M**	**0.000 M**
Change	**- x**		**+ x**	**+ x**
Equilibrium	**0.100 - x**		**+ x**	**+ x**

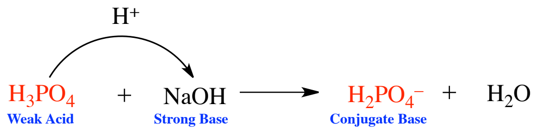
$$K_a = \frac{x^2}{[\ ]_0 - x} \quad \therefore \quad x = [H^+] \quad \therefore \quad pH = -\log[H^+]$$

$$\frac{[\ ]_0}{K_a} > 500$$ **5% Approximation Method**

Before 1^{st} Equivalence Point

The titration of 50.0 mL of 0.100 M H_3PO_4 with 30.00 mL of 0.100 M NaOH

	H_3PO_4 (Weak Acid) +	NaOH (Strong Base) $\longrightarrow$	$H_2PO_4^-$ (Conjugate Base) +	H_2O
Initial	**0.00500 moles**	**0.00100 moles**	**0.00000 moles**	✕
Change	**- 0.00300 moles**	**- 0.00300 moles**	**+ 0.00300 moles**	
Final	**0.00200 moles**	**0**	**0.00300 moles**	



- **Weak acid** and **Conjugate base** will be present at the end.
- Use the Henderson Hasselbalch Equation.

$$pH = pKa_1 + \log\left(\frac{\text{Conjugate Base}}{\text{Weak Acid}}\right)$$

At 1^{st} Equivalence Point

The titration of 50.0 mL of 0.100 M H_3PO_4 with 50.00 mL of 0.100 M NaOH

	H_3PO_4 (Weak Acid) +	NaOH (Strong Base) $\longrightarrow$	$H_2PO_4^-$ (Conjugate Base) +	H_2O
Initial	**0.00500 moles**	**0.00500 moles**	**0.00000 moles**	✕
Change	**- 0.00500 moles**	**- 0.00500 moles**	**+ 0.00500 moles**	
Final	**0**	**0**	**0.00500 moles**	

$$F = [HA]_0 \left(\frac{V_{\text{Initial Acid}}}{V_{\text{Solution}}}\right)$$

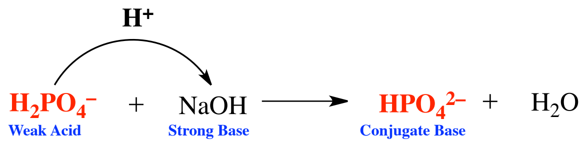
$$[H^+] = \sqrt{\frac{K_1K_2F + K_1K_W}{K_1 + F}}$$

CONCEPT: POLYPROTIC ACID TITRATIONS PT.2

After 1st Equivalence Point

The titration of 50.0 mL of 0.100 M H_3PO_4 with 70.00 mL of 0.100 M NaOH

	$H_2PO_4^-$ Weak Acid	+ NaOH Strong Base	$\longrightarrow$ HPO_4^{2-} Conjugate Base	+ H_2O
Initial	**0.00500 moles**	**0.00200 moles**	**0.00000 moles**	
Change	**- 0.00200 moles**	**- 0.00200 moles**	**+ 0.00200 moles**	
Final	**0.00300 moles**	**0**	**0.00200 moles**	



- **Weak acid** and **Conjugate base** will be present at the end.
- Use the Henderson Hasselbalch Equation.

$$pH = pKa_2 + \log\left(\frac{\text{Conjugate Base}}{\text{Weak Acid}}\right)$$

At 2nd Equivalence Point

The titration of 50.0 mL of 0.100 M H_3PO_4 with 100.00 mL of 0.100 M NaOH

$$F = [HA]_0\left(\frac{V_{\text{Initial Acid}}}{V_{\text{Solution}}}\right)$$

$$[H^+] = \sqrt{\frac{K_2K_3F + K_2K_w}{K_2 + F}}$$

After 2nd Equivalence Point

The titration of 50.0 mL of 0.100 M H_3PO_4 with 115.00 mL of 0.100 M NaOH

$$[OH^-] = [OH^-]_0\left(\frac{V_{\text{Excess Base}}}{V_{\text{Base}} + V_{\text{Acid}}}\right)$$

$$pOH = -\log[OH^-] \;\therefore\; pH = 14 - pOH$$