CONCEPT: DIPROTIC ACID TITRATIONS PT.1

Equivalence Volume (V_e)

The titration of 100.0 mL of 0.100 M H_2SO_3 with 0.050 M KOH

Before any Strong Base is added

The titration of 100.0 mL of 0.100 M H_2SO_3 with 0.00 mL of 0.050 M KOH

	H_2SO_3	+	H_2O	$\rightleftharpoons$	HSO_3^-	+	H_3O^+
Initial	0.100 M				0.00 M		0.00 M
Change	- x				+ x		+ x
Equilibrium	0.100 - x				+ x		+ x

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

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

Before 1st Equivalence Point

The titration of 100.0 mL of 0.100 M H_2SO_3 with 75.00 mL of 0.050 M KOH

	H_2SO_3 Weak Acid	+	KOH Strong Base	$\longrightarrow$	HSO_3^- Conjugate Base	+	H_2O
Initial	0.01000 moles		0.00375 moles		0.00000 moles		
Change	- 0.00375 moles		- 0.00375 moles		+ 0.00375 moles		
Final	0.00625 moles		0		0.00375 moles		
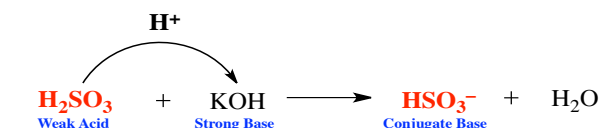
$$\overset{H^+}{\frown}$$

H_2SO_3 (Weak Acid) + KOH (Strong Base) $\longrightarrow$ HSO_3^- (Conjugate Base) + H_2O

- **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 1st Equivalence Point

The titration of 100.0 mL of 0.100 M H_2SO_3 with 200.00 mL of 0.050 M KOH

	H_2SO_3 Weak Acid	+	KOH Strong Base	$\longrightarrow$	HSO_3^- Conjugate Base	+	H_2O
Initial	0.01000 moles		0.00100 moles		0.00000 moles		
Change	- 0.00100 moles		- 0.00100 moles		+ 0.00100 moles		
Final	0		0		0.00100 moles		

$$F = [HA]_0\left(\frac{V_{\text{Initial Acid}}}{V_{\text{Solution}}}\right)$$
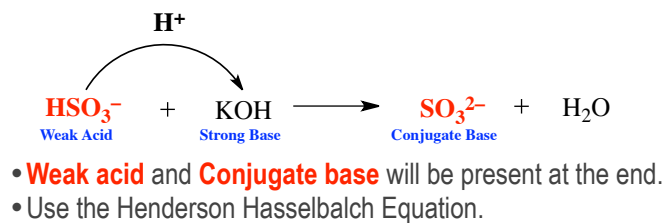
$$[H^+] = \sqrt{\frac{K_1 K_2 F + K_1 K_W}{K_1 + F}}$$

CONCEPT: DIPROTIC ACID TITRATIONS PT.2

After 1st Equivalence Point

The titration of 100.0 mL of 0.100 M H_2SO_3 with 250.00 mL of 0.050 M KOH

	HSO_3^-	+	KOH	$\longrightarrow$	SO_3^{2-}	+	H_2O
	Weak Acid		Strong Base		Conjugate Base		
Initial	0.01000 moles		0.00250 moles		0.00000 moles		
Change	- 0.00250 moles		- 0.00250 moles		+ 0.00250 moles		
Final	0.00750 moles		0		0.00250 moles		

H^+

HSO_3^- + KOH $\longrightarrow$ SO_3^{2-} + H_2O
Weak Acid Strong Base Conjugate Base

- **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 100.0 mL of 0.100 M H_2SO_3 with 400.00 mL of 0.050 M KOH

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

$$K_{b1} = \frac{x^2}{F-x} \quad \therefore \quad x = [OH^-] \quad \therefore \quad pOH = -\log[OH^-]$$

$$pH = -\log[H^+]$$

After 2nd Equivalence Point

The titration of 100.0 mL of 0.100 M H_2SO_3 with 420.00 mL of 0.050 M KOH

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

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

## PRACTICE: DIPROTIC ACID TITRATIONS CALCULATIONS 1

EXAMPLE 1: Calculate the pH of 100 mL of a 0.25 M H_2CO_3 when 70.0 mL of 0.25 M NaOH are added. $K_{a1} = 4.3 \times 10^{-7}$ and $K_{a2} = 5.6 \times 10^{-11}$.

EXAMPLE 2: Calculate the pH of 75.0 mL of a 0.10 M of phosphorous acid, H_3PO_3, when 80.0 mL of 0.15 M NaOH are added. $K_{a1} = 5.0 \times 10^{-2}$, $K_{a2} = 2.0 \times 10^{-7}$.

PRACTICE: DIPROTIC TITRATIONS CALCULATIONS 2

EXAMPLE 1: Find the pH when 100.0 mL of a 0.1 M dibasic compound B (pK_{b1} = 4.00; pK_{b2} = 8.00) was titrated with 11 mL of a 1.00 M HCl.

EXAMPLE 2: Carbonic acid, H_2CO_3, is a diprotic acid that dissociates, losing its two protons, to create bicarbonate, HCO_3^-, and carbonate, CO_3^{2-}, according to the following reactions given below:

$$H_2CO_3 \,(aq) \; \rightleftharpoons \; HCO_3^- \,(aq) \; + \; H^+ \,(aq) \; \rightleftharpoons \; CO_3^{2-} \,(aq) \; + \; H^+ \,(aq)$$
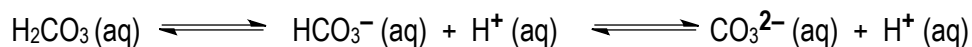
As a diprotic acid system, it has two dissociation constants that pK_{a1} = 6.30 and pK_{a2} = 10.30 for the two steps. In the reaction you titrate 50.0 mL solution of 0.50 M H_2CO_3 with 1.00 M solution of NaOH. What would be the expected pH after the addition of 35 mL of the NaOH titrant?