

Titration Calculations

Strong Acid/Strong Base Calculations

- (1) Use balanced equation to do stoichiometric calculation.
- (2) Determine pH from amount of strong acid/base that is in excess.

Note: At stoichiometry point of equal acid and base, pH = 7.

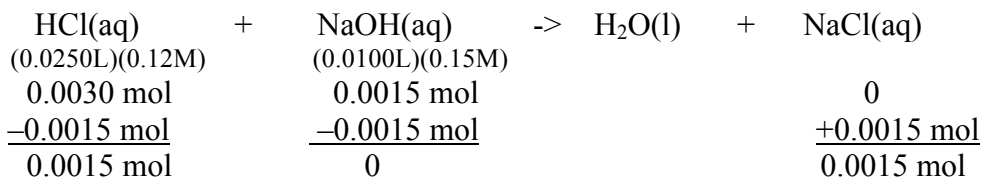
Example:

What is pH after 0.0 mL, 10.0 mL, at equivalence point, and 50.0 mL of base has been added during a titration to 25.0 mL of a 0.12M HCl solution with 0.15M NaOH solution?

For strong acid/base titration, perform stoichiometry calculation first; then calculation resulting concentration with total volume; finally, calculate pH directly.

(A) 0.0 mL base: Solution is 0.12M HCl $\text{pH} = -\log[\text{H}^+] = -\log(0.12) = 0.92$

(B) 10.0 mL added base:



$$[\text{HCl}] = 0.0015 \text{ mol} / 0.0350 \text{ L} = 0.043 \text{ M}$$

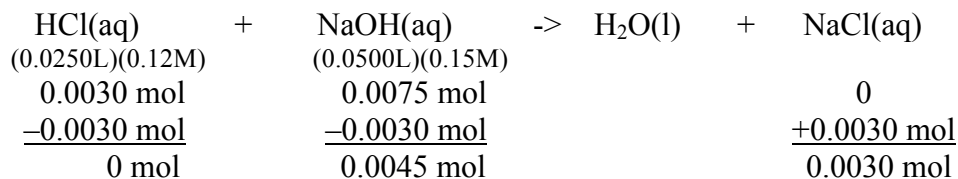
Therefore **since strong acid**: $[\text{H}^+] = 0.043 \text{ M}$ so $\text{pH} = -\log(0.043) = 1.37$

(C) At Equivalence Point:

$$\begin{aligned} \text{Volume of base added} &= (0.0030 \text{ mol HCl})(1 \text{ mol NaOH} / 1 \text{ mol HCl})(1 \text{ L} / 0.15 \text{ mol NaOH}) \\ &= 0.020 \text{ L} = 20. \text{ mL added base} \end{aligned}$$

Since NaCl does not hydrolyze water, pH is neutral 7.00.

(D) 50.0 mL added base:



$$[\text{NaOH}] = 0.0045 \text{ mol} / 0.0750 \text{ L} = 0.060 \text{ M}$$

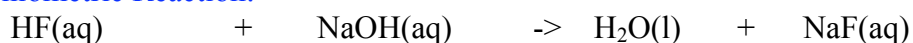
Therefore **since strong base left**: $[\text{OH}^-] = 0.060 \text{ M}$ so $\text{pOH} = -\log(0.060) = 1.22$
 $\text{pH} = 12.78$

Weak Acid/Strong Base Calculations

What is pH after 0.0 mL, 10.0mL, at equivalence point, and 50.0 mL of base has been added during a titration to 25.0 mL of a 0.12M HF solution with 0.15M NaOH solution?
 $K_a = 6.8 \times 10^{-4}$

- (1) Use balanced equation to do **stoichiometric** calculation.
- (2) Determine new concentrations by dividing by total volume.
- (3) Use appropriate **equilibrium** reaction and ICE chart to determine pH.

Stoichiometric Reaction:



Equilibrium Reaction:



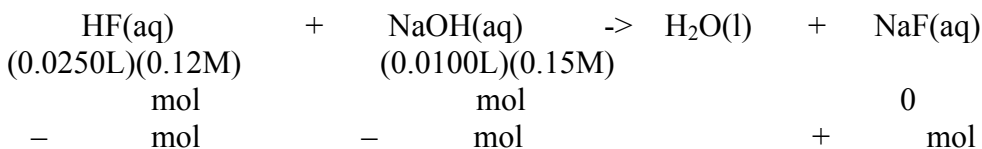
(A) Addition of 0.0 mL of base:
Only weak acid present.

	HF (aq)	+	H ₂ O	⇌	H ₃ O ⁺ (aq)	+	F ⁻ (aq)
I							
C							
E							

(B) What is pH after 10.0mL of 0.15M NaOH solution has been added to 25.0 mL of 0.12M HF solution? $K_a = 6.8 \times 10^{-4}$

- (1) Use balanced equation to do stoichiometric calculation.
- (2) Determine new concentrations by dividing by total volume.
- (3) Use appropriate equilibrium reaction and ICE chart to determine pH.

(1) **Stoichiometric** Reaction:



(2) New concentrations:

[HF] =

[F⁻] =

(3) **Equilibrium** Reaction:

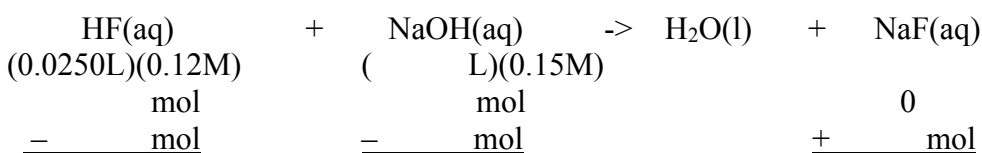
	HF (aq)	+	H ₂ O	⇌	H ₃ O ⁺ (aq)	+	F ⁻ (aq)
I							
C							
E							

(C) What is pH at equivalence point?

First need to determine volume at equivalence point.

- (1) Use balanced equation to do stoichiometric calculation.
- (2) Determine new concentrations by dividing by total volume.
- (3) Use appropriate equilibrium reaction and ICE chart to determine pH.

(1) **Stoichiometric** Reaction:



(2) New concentrations:

$$[\text{HF}] =$$

$$[\text{F}^-] = \quad K_b = \frac{1 \times 10^{-14}}{6.8 \times 10^{-4}} = 1.5 \times 10^{-11}$$

(3) **Equilibrium** Reaction:

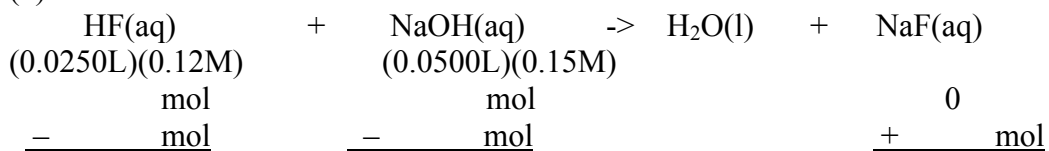
Only conjugate base now left. So must use equilibrium reaction for conjugate base and calculate K_b .

	$\text{F}^- (\text{aq}) + \text{H}_2\text{O} \rightleftharpoons \text{OH}^- (\text{aq}) + \text{HF} (\text{aq})$
I	
C	
E	

(D) What is pH after 50.0mL of 0.15M NaOH solution has been added to 25.0 mL of 0.12M HF solution? $K_a = 6.8 \times 10^{-4}$

- (1) Use balanced equation to do stoichiometric calculation.
- (2) Determine new concentrations by dividing by total volume.
- (3) Use appropriate equilibrium reaction and ICE chart to determine pH.

(1) **Stoichiometric** Reaction:



(2) New concentrations:

$$[\text{OH}^-] =$$

$$[\text{F}^-] =$$

$$K_b = \frac{1 \times 10^{-14}}{6.8 \times 10^{-4}} = 1.5 \times 10^{-11}$$

(3) **Equilibrium** Reaction:

	$\text{F}^- (\text{aq}) + \text{H}_2\text{O} \rightleftharpoons \text{OH}^- (\text{aq}) + \text{HF} (\text{aq})$
I	
C	
E	