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, 10.0mL, 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 pH = -log[H+] = -log(0.12) = 0.92

(B) 10.0mL added base:

$HCl(aq)$	+	$NaOH(aq)$	->	$H_2O(l)$	+	$NaCl(aq)$
(0.0250L)(0.12M)		(0.0100L)(0.15M)				
0.0030 mol		0.0015 mol				0
–0.0015 mol		–0.0015 mol				+0.0015 mol
0.0015 mol		0				0.0015 mol

[HCl] = 0.0015 mol/0.0350L = 0.043 M
Therefore since strong acid: $[H^+]$ = 0.043 M so pH = –log (0.043) = 1.37

(C) At Equivalence Point:
Volume of base added = (0.0030mol HCl)(1mol NaOH/1mol HCl)(1L/0.15mol NaOH)
= 0.020 L = 20. mL added base

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

(D) 50.0mL added base:

$HCl(aq)$	+	$NaOH(aq)$	->	$H_2O(l)$	+	$NaCl(aq)$
(0.0250L)(0.12M)		(0.0500L)(0.15M)				
0.0030 mol		0.0075 mol				0
–0.0030 mol		–0.0030 mol				+0.0030 mol
0 mol		0.0045 mol				0.0030 mol

[NaOH] = 0.0045 mol/0.0750L = 0.060 M
Therefore since strong base left: $[OH^-]$ = 0.060 M so pOH = –log (0.060) = 1.22
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:

$$HF(aq) + NaOH(aq) \rightarrow H_2O(l) + NaF(aq)$$

Equilibrium Reaction:

$$HF(aq) + H_2O(l) \rightarrow H_3O^+(aq) + F^-(aq)$$

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

	HF (aq)	+	H_2O	⇔	H_3O^+ (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:

HF(aq)	+	NaOH(aq)	->	$H_2O(l)$	+	NaF(aq)
(0.0250L)(0.12M)		(0.0100L)(0.15M)				
mol		mol				0
– mol		– mol				+ mol

(2) New concentrations:

[HF] =

$[F^-]$ =

(3) Equilibrium Reaction:

	HF (aq)	+	H_2O	⇔	H_3O^+ (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:

HF(aq)	+	NaOH(aq)	->	$H_2O(l)$	+	NaF(aq)
(0.0250L)(0.12M)		(L)(0.15M)				
mol		mol				0
– mol		– mol				+ mol

(2) New concentrations:

[HF] =

$[F^-]$ =

$$K_b = \frac{1x10^{-14}}{6.8x10^{-4}} = 1.5x10^{-11}$$

(3) Equilibrium Reaction:

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

	F^- (aq)	+	H_2O	⇔	OH^-(aq)	+	HF (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:

$HF(aq)$	+	$NaOH(aq)$	->	$H_2O(l)$	+	$NaF(aq)$
(0.0250L)(0.12M)		(0.0500L)(0.15M)				
mol		mol				0
– mol		– mol				+ mol

(2) New concentrations:

$[OH^-]$ =

$[F^-]$ =

$$K_b = \frac{1x10^{-14}}{6.8x10^{-4}} = 1.5x10^{-11}$$

(3) Equilibrium Reaction:

	F^- (aq)	+	H_2O	⇔	OH^-(aq)	+	HF (aq)
I							
C							
E							