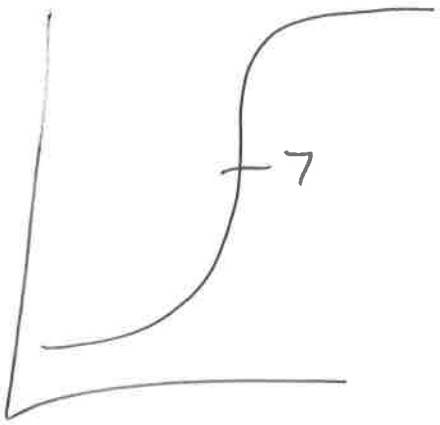
AP Chemistry
TITRATION REVIEW

Four Main Types of Titrations

Strong Acid-Strong Base



$H^+ + OH^- \rightarrow H_2O$

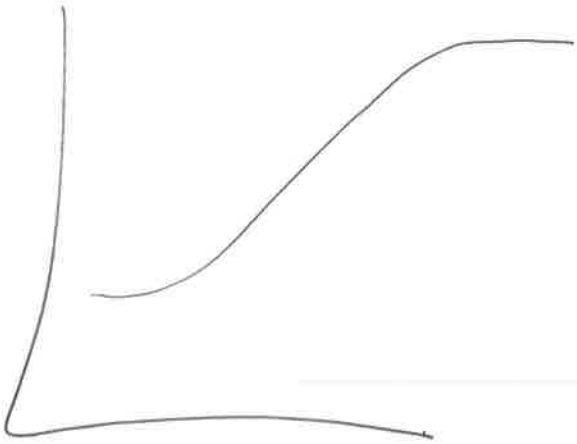
~~① Before EQ pt, acid dominates~~

just do BCA

fewer moles gets consumed

find pH w/ total vol & remaining moles

Weak Acid- Strong Base

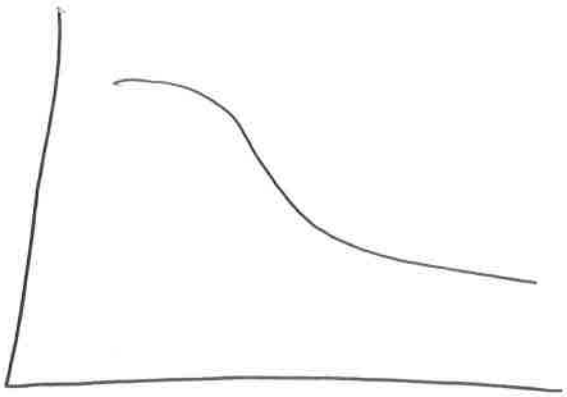


① Before EQ pt

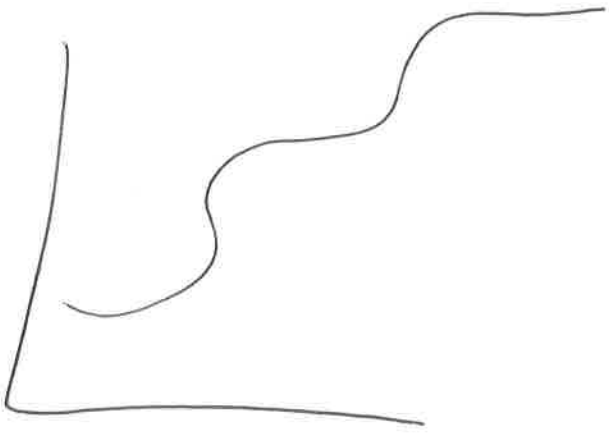
Acid + OH^- → conj. ion + H_2O

BCA table

Weak Base-Strong Acid



Polyprotic Acid



Example: C_6H_5COOH WA-SB

Benzoic acid is a weak monoprotic acid ($K_a = 6.3 \times 10^{-5}$). If 25.0 mL of a 0.100*M* solution of benzoic acid is titrated against 0.050 M sodium hydroxide:

a. Calculate the pH before any titrant is added
b. Calculate the pH halfway to the equivalence point
c. Calculate the pH at the equivalence point
d. Calculate the pH at 25mL past the equivalence point
e. Sketch the titration curve

d) $C_6H_5COOH + OH^- \rightarrow C_6H_5COO^- + H_2O$

B 0.0025 0.0375 ∅

C −0.0025 −0.0025 +0.0025

A ∅ 0.00125 mol

$\frac{0.00125\,mol}{0.1\,L} = 0.0125M = [OH^-]$

$pOH = 1.9$

$pH = 12.1$

Eq pt $= \frac{0.1\,mol}{1\,L} \times 0.025\,L =$

$\frac{0.0025\,mol}{1} \times \frac{1\,L}{0.05\,mol} =$

$0.05\,L = 50\,mL$

a) $C_6H_5COOH \rightleftharpoons C_6H_5COO^- + H^+$

I	0.1	∅	∅
C	−x	+x	+x
E	0.1−x	x	x

$6.3 \times 10^{-5} = \frac{x^2}{0.1}$

$x = [H^+] = 0.0025$

$pH = 2.6$

b) $pH = pK_a = -\log(6.3 \times 10^{-5}) = 4.2$

c) base dominates

$C_6H_5COOH + OH^- \rightarrow C_6H_5COO^- + H_2O$

B 0.0025 0.0025 ∅

C −0.0025 −0.0025 +0.0025

A ∅ ∅ $\frac{0.0025\,mol}{0.075\,L} = 0.033M$

Total vol = 75mL

$C_6H_5COO^- \rightleftharpoons C_6H_5COOH + OH^-$

I	0.033	∅	∅
C	−x	+x	+x
E	0.033−x	x	x

$K_b = \frac{1 \times 10^{-14}}{6.3 \times 10^{-5}} = 1.59 \times 10^{-10}$

$1.59 \times 10^{-10} = \frac{x^2}{0.033}$

$x = 2.3 \times 10^{-6} M = [OH^-]$

$pOH = 5.64$ $pH = 8.36$

5A-5B

Example:
35.0 mL of a 0.150*M* solution of hyrdobromic acid is titrated against 0.100 M sodium hydroxide:

a. Calculate the pH before any titrant is added
b. Calculate the pH halfway to the equivalence point
c. Calculate the pH at the equivalence point
d. Calculate the pH at 25mL past the equivalence point
e. Sketch the titration curve

$\frac{0.15 mol}{L} \times 0.035L =$

$\frac{0.00525 mol}{1} \times \frac{1L}{0.1 mol} =$

$0.0525L = 52.5L$

a) $HBr = 0.15M$

pH = 0.82

b) $H^+ + OH^- \rightarrow H_2O$

B 0.00525 0.002625
C −0.002625
A 0.002625 mol

$\frac{0.002625 mol}{0.06125L} = 0.043M = [H^+]$

$\frac{52.5}{2} = 0.02625L$

$0.02625L \times \frac{1 mol}{1M} = 0.002625 mol$

pH = 1.37

c) ~~$H^+ + OH^- \rightarrow H_2O$~~

pH = 7

d) $H^+ + OH^- \rightarrow H_2O$

B 0.00525 0.00775
C −0.00525
A 0.0025 mol

$\frac{0.0025 mol}{0.1125L} = 0.022M = [OH^-]$

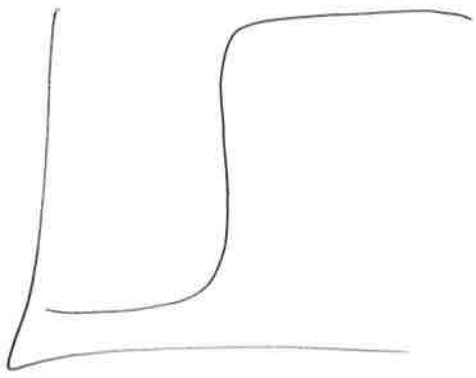
$52.5 + 25 = 77.5mL$

$0.1M \times 0.0775L = 0.00775$

pOH = 1.65

pH = 12.35

e)



WB – SA

Example:
A 20.0 mL sample of 0.10 M CH_3NH_2 (methyl amine) is titrated with 0.15 M HCl. The K_b for $CH_3NH_2 = 4.2 \times 10^{-4}$.

a. Calculate the pH before any titrant is added
b. Calculate the pH at the equivalence point
c. Calculate the pH at 25mL past the equivalence point
d. Sketch the titration curve

$\frac{0.1\,mol}{L} \times 0.02L = 0.002\,mol$

$\frac{0.002\,mol}{1} \times \frac{1L}{0.15\,mol} = 0.013L$

a) $CH_3NH_2 \rightleftharpoons CH_3NH_3^+ + OH^-$

	CH_3NH_2	$CH_3NH_3^+$	OH^-
I	0.1	∅	∅
C	−x	+x	+x
E	0.1 − x	x	x

$4.2 \times 10^{-4} = \frac{x^2}{0.1-x}$ $\quad x = 0.0065$

$pOH = 2.19$

$\boxed{pH = 11.81}$

b) $CH_3NH_2 + H^+ \longrightarrow CH_3NH_3^+ + H_2O$

	CH_3NH_2	H^+	$CH_3NH_3^+$
B	0.002	0.002	∅
C	−0.002	−0.002	+0.002
A	∅	∅	0.002 mol

$\frac{0.002\,mol}{0.033L} = 0.061M$

$CH_3NH_3^+ \rightleftharpoons CH_3NH_2 + H^+$

	$CH_3NH_3^+$	CH_3NH_2	H^+
I	0.061	∅	∅
C	−x	+x	+x
E	0.061 − x	x	x

$K_a = 2.4 \times 10^{-11} = \frac{x^2}{0.061 - x}$

$x = 1.21 \times 10^{-6} M$

$\boxed{pH = 5.92}$

c) $CH_3NH_2 + H^+ \longrightarrow CH_3NH_3^+ + H_2O$

	CH_3NH_2	H^+	$CH_3NH_3^+$
B	0.002	0.0037	∅
C	−0.002	−0.002	+0.002
A	∅	0.0037 mol	0.002

$0.038L \times 0.15M =$

$\frac{0.0037\,mol}{0.058L} = 0.064M$

$\boxed{pH = 1.19}$