Today

Titration
determining something about an unknown
by reacting it with a known solution

Neutralization (again)
we'll need this to figure out titration

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Titration

Why do a titration.

You have a solution with an unknown property

Unknown Concentration?
Unknown Ka (Kb)?
Both.

Slowly neutralize the solution by adding
a strong base (acid)
monitor the pH with each addition

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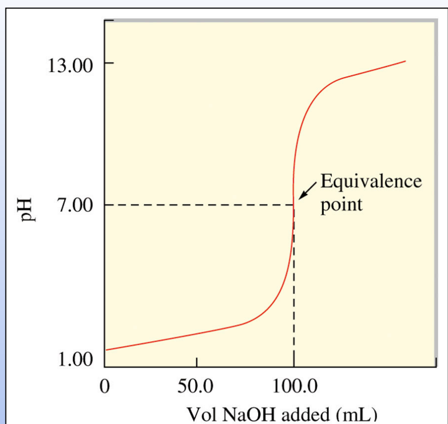
Last Time Strong Acid/Strong Base Titration



original solution 50 mL HCl
adding .1 M NaOH
at equivalence point

same number of moles of base
.1L x .1M = 0.01 moles OH^-

therefore the solution originally
had 0.01 moles H^+

concentration was .2 M

at the equivalence point we have
equal number of moles of acid and base

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Neutralize first
Then look at the equilibrium

imagine a 100 mL solution with 0.1 moles of HCl
we add .01 moles of NaOH in each titration step (10 mL of 1M)

Initial		After Neutralization		Volume (L)	Equilibrium	
mol H^+	mol OH^-	mol H^+	mol OH^-		pH	pOH
0.1	0.01	0.09	0.00	0.11	0.09	13.91
0.09	0.01	0.08	0.00	0.12	0.18	13.82
0.08	0.01	0.07	0.00	0.13	0.27	13.76
....						
0.02	0.01	0.01	0.00	0.19	1.28	12.72
0.01	0.01	0.00	0.00	0.20	7.00	7.00
0.0	0.01	0.0	0.01	0.21	12.67	1.33
0.0	0.02	0.0	0.02	0.22	12.86	1.04

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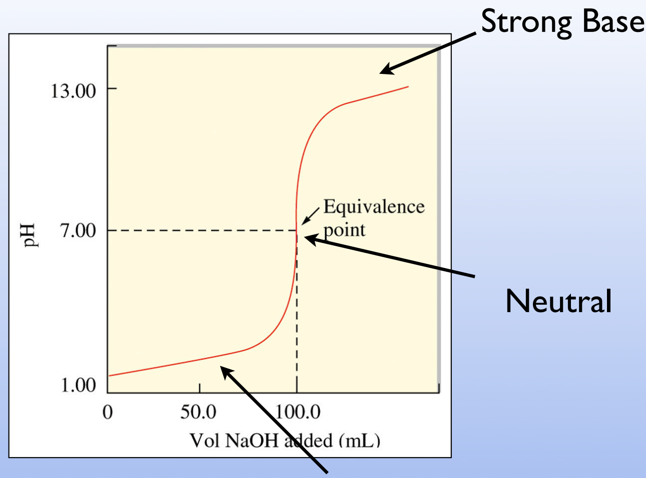
Strong Acid/Strong Base Titration



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What volume of a 1 M NaOH will you need to add to 200 mL of a 0.2 M solution of HCl to neutralize it?

A. 10 mL

B. 20 mL

C. 30 mL

D. 40 mL

E. 400 mL

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At the endpoint of your titration you have added 40 mL of a 1M NaOH solution to 200 mL of an unknown HCl solution. What was the concentration of the HCl?

A. 0.1 M

B. 0.2 M

C. 0.4 M

D. 1 M

E. 2 M

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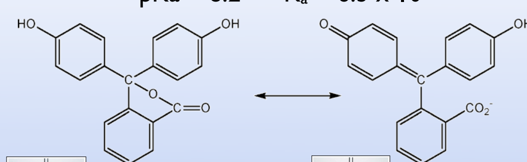
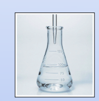
Finding the endpoint (equivalence point)
Indicator dye

Phenolphthalein

pKa = 8.2 $K_a = 6.3 \times 10^{-9}$



amount of indicator is so small it doesn't affect the pH, but the equilibrium of the dye is strongly affected by the pH



Colourless
HA

Pink
A^-

$$K_a = [H^+] \times \frac{[A^-]}{[HA]}$$

$$= [H^+] \times \frac{\text{Pink}}{\text{Clear}}$$

$[H^+] > 6.3 \times 10^{-9}$
pH < 8.2

$\frac{\text{Pink}}{\text{Clear}} < 1$

$[H^+] < 6.3 \times 10^{-9}$
pH>8.2

$\frac{\text{Pink}}{\text{Clear}} > 1$

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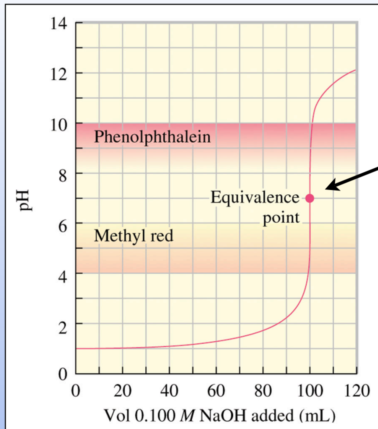

color just barely changing for Phenolpthalein

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Bromophenol Blue has a pK_a of around 4.
When it is protonated (HA form) it is green,
when it is deprotonated (A^- form) it is blue.

What color would in be in a solution in which the pH was 8?

A. blue

B. green

C. a mix of blue and green

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Titration with weak acid/base

All the same
Neutralize first
Then equilibrium

Neutralization reactions

$H^+(aq) + OH^-(aq) \longleftrightarrow H_2O(l)$

$H^+(aq) + A^-(aq) \longleftrightarrow HA(aq)$

$H^+(aq) + B(aq) \longleftrightarrow BH^+(aq)$

$OH^-(aq) + HA(aq) \longleftrightarrow A^-(aq)$

$OH^-(aq) + BH^+(aq) \longleftrightarrow B(aq)$

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I have a 100 mL of a 1 M solution of acetic acid
I add 100 mL of 0.5 M NaOH
What remains in the solution?

A. 0.1 moles of acetic acid

B. 0.1 moles acetic acid and 0.05 moles of acetate

C. 0.05 moles of acetic acid and 0.05 moles of acetate

D. 0.05 moles of acetic acid and 0.1 moles of acetate

E. 0.1 moles of acetate

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If I have a solution that has
0.05 moles of acetic acid and
0.05 moles of sodium acetate
what do I have?

A. strong acid solution

B. weak acid solution

C. buffer

D. weak base

E. strong base

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Neutralization of a weak acid or weak base
will yield a buffer
because you generate
the conjugate base or acid

$$H^+(aq) + A^-(aq) \longleftrightarrow HA(aq)$$

$$OH^-(aq) + HA(aq) \longleftrightarrow A^-(aq)$$

Buffer will remain until
you neutralize all of the initial acid or base

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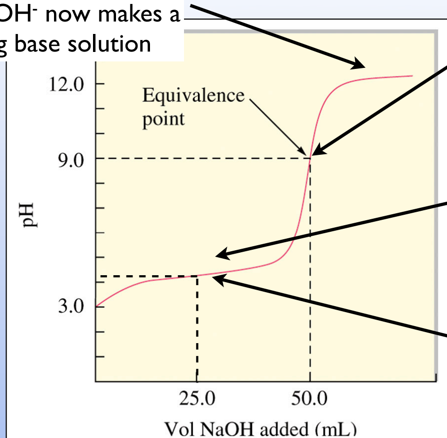
Titrating a weak acid

all HA neutralized at
equivalence point
Adding OH^- now makes a
strong base solution



Equivalence point
All of HA converted to A^-
Now a weak base solution

buffer region

half-way to
equivalence point

half of HA
converted to A^-

$[HA] = [A^-]$
$[H^+] = K_a$
$pH = pK_a$

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Calc on Doc Cam

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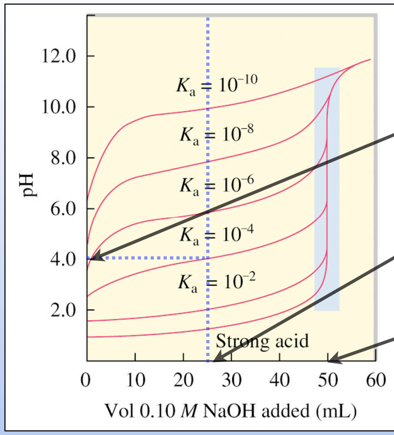

at the 1/2 equivalence point pH = pKa

equivalence point is 50 mL
half equivalence point is 25 mL

end point = equivalence point
read it off the graph
it is 50 mL
tells us the concentration of
the solution being titrated
moles acid = moles base

Example of 6 acids with different Ka's but
the same concentration
Same concentration will produce the
same equivalence point

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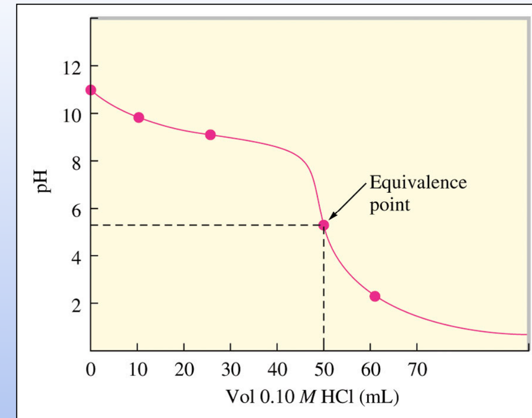
Weak base titrated with strong acid



Basic solution starts at high pH (basic) goes to low (acid)

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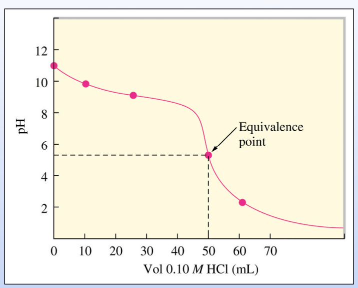
Weak base titrated with strong acid



Base solution has a volume of 100 mL.
What is the concentration?

A. 0.05 M

B. 0.1 M

C. 0.15 M

D. 0.20 M

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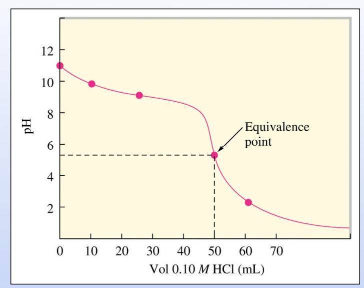
Weak base titrated with strong acid



What is the Kb of the base?

A. 1×10^{-4}

B. 3×10^{-5}

C. 1×10^{-5}

D. 3×10^{-6}

E. 1×10^{-6}

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Rolaids® contain about 0.1 g of Magnesium Hydroxide
Why in the world would you ever put such a thing in your mouth?

A. 0.1 g is nothing. I each 10-20 g NaOH daily just for laughs

B. Acids are dangerous by bases as quite safe

C. The saliva in my mouth is acidic enough to "handle it"

D. $Mg(OH)_2$ is not soluble in water

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Solubility Equilibria

$$Mg(OH)_2\ (s) \longleftrightarrow Mg^{2+}(aq) + 2OH^-(aq)$$

$$K_{sp} = [Mg^{2+}][OH^-]^2 = 5.6 \times 10^{-12}$$

OH^- that is dissolved neutralizes any H^+
then more OH^- dissolves...repeat

end result is a very slightly basic solution

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