Today

How to solve all acid/base problems
(except the ones we'll do next week)

Strong Acid
Weak Acid
Buffer
Weak Base
Strong Base

If you're having trouble go step by step

1. Remove the spectator ions (Na^+, Cl^-, NO_3^-,....)
2. Are there any strong acids or bases
3. Are there any weak acids or bases
4. Do I neutralize?
   (strong acid and any base. Strong base and any acid)
5. Neutralize
   convert everything to moles
   write down the correct neutralization reaction
   find the limiting reagent
   final the compounds in the solution after neutralization
   convert back to molarity
6. Identify what is in solution and solve the equilibrium
7. convert to the appropriate answer pH, pOH, $[H^+]$, ...

what is the pH of a solution of
100 mL of a 1M weak acid with a K_a of 10^{-4}
and 50 mL of 1M NaOH?

spectator ion? Na^+

(H^+) strong acid? No
(OH^-) strong base? YES

(HA or BH^+) weak acid? YES
(B or A^-) weak base? No

Do I need to neutralize?

Yes. I have a strong base and an acid

what is the pH of a solution of
100 mL of a 1M weak acid with a K_a of 10^{-4}
and 50 mL of 1M NaOH?

Convert to moles

.1L x 1M = 0.1 moles of HA

.05L x 1M = 0.05 moles of OH^-

ICAN

not ICE

neutralization reaction

$$OH^-(aq) + HA(aq) \longrightarrow A^-(aq) + H_2O(l)$$

	$OH^-(aq)$	$HA(aq)$	$A^-(aq)$
init	0.05 moles	0.1 moles	0 moles
change	-0.05 moles	-0.05 moles	+0.05 moles
after neutral	0 moles	0.05 moles	0.05 moles

what is the pH of a solution of
100 mL of a 1M weak acid with a K_a of 10^{-4}
and 50 mL of 1M NaOH?

neutralization reaction

$$OH^-(aq) + HA(aq) \longrightarrow A^-(aq) + H_2O(l)$$

	$OH^-(aq)$	$HA(aq)$	$A^-(aq)$
after neutral	0 moles	0.05 moles	0.05 moles

$[HA] = 0.05/.15 = .333$ $[A^-] = 0.05/.15 = .333$

What "kind" of solution is this?

buffer

How do I calculate the pH for different solutions?

Strong Acid

$[H^+] = C_a$

Strong Base

$[OH^-] = C_b$

Weak Acid

$[H^+] = \text{sqrt}(K_a C_a)$

Weak Base

$[OH^-] = \text{sqrt}(K_b C_b)$

Buffer

$[H^+] = K_a C_a / C_b$

Buffer

$[OH^-] = K_b C_b / C_a$

what is the pH of a solution of
100 mL of a 1M weak acid with a K_a of 10^{-4}
and 50 mL of 1M NaOH?

$[HA] = 0.05/.15 = .333$ $[A^-] = 0.05/.15 = .333$

Buffer

$[H^+] = K_a C_a/C_b$

Buffer

$[H^+] = 10^{-4}\ (.333)/(.333) = 10^{-4}$

pH = 4 pOH = 10

What is the pH of a solution formed by mixing
100 mL of 1 M Acetic Acid and 100 mL of 1 M LiOH?

what acid/base species are in this solution to start?

A. a strong acid and a strong base

B. a weak acid and a strong base

C. a weak acid and a weak base

D. a strong acid and a weak base

E. a strong acid and a weak acid

Acetic Acid = HA
$NaOH = OH^-$

What is the pH of a solution formed by mixing
100 mL of 1 M Acetic Acid and 100 mL of 1 M LiOH?

Do I need to neutralize this solution?

A. yes ← Strong base and an acid

$OH^- + HA \rightarrow A^- \quad H_2O$

B. no

C. it depends on the molecular weight of acetic acid

What is the pH of a solution formed by mixing
100 mL of 1 M Acetic Acid and 100 mL of 1 M LiOH?

What is left in solution after neutralization?

A. .1 M HA

B. .1 M A^-

C. .05 M of HA and .05 M of A^-

D. .05 M of OH^-

.1 L x 1M = .1 HA
.1L x 1M = .1 OH^-
note: this would be the equivalence point in a titration

What is the pH of a solution formed by mixing
100 mL of 1 M Acetic Acid and 100 mL of 1 M LiOH?

What "kind" of equilibrium problem is this?

A. strong acid

B. weak acid

C. buffer

D. weak base

E. strong base

A^- is a weak base
no HA in solution
no H^+
no OH^-

What is the pH of a solution formed by mixing
100 mL of 1 M Acetic Acid and 100 mL of 1 M LiOH?

If the K_a of acetic acid 10^{-5} what is K_b for acetate (A^-)?

A. 10^{-5}

B. 10^{-7}

C. 10^{-9}

D. 10^{-14}

K_b for A^- = K_w/K_a for HA

$10^{-14}/10^{-5} = 10^{-9}$

What is the pH of a solution formed by mixing
100 mL of 1 M Acetic Acid and 100 mL of 1 M LiOH?

What is the pH of this solution given that we end up with
0.1 moles of A^- with a K_b of 10^{-9}?

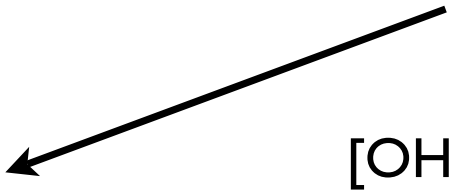
A. 3.8

B. 4.65

C. 7

D. 9.35

E. 11.2



It is a base so it should be > 7

$C_b = .1/.2 = 0.5$ M

$[OH^-] = \text{sqrt}(K_bC_b) = \text{sqrt}(5\times10^{-1}\times10^{-9}) = \text{sqrt}(5\times10^{-10}) = 2.23\times10^{-5}$

pOH = 4.65 pH = 9.35

How to get a buffer

Start with HA and A^-
or BH^+ and B

partially neutralize HA with OH^-
this will generate A^-

partially neutralize B with H^+
this will generate BH^+

Which of the following can make a buffer?

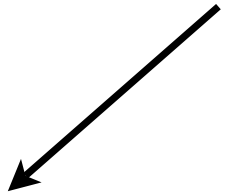
A. a strong acid and a weak acid

B. a strong acid and a strong base

C. a strong acid and a weak base

D. a strong base and a weak base

H^+ neutralizes B to make some BH^+



mixing equal volumes of equal concentrations solutions which of the following is a buffer?

A. HNO_3 and $NaNO_3$

B. HCl and KCl

C. HF and NaF

D. $HClO_4$ and $CsClO_4$

HA = HF

A^- = F^-

HA and A^- in the same solution

buffer

Let's look at some examples

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

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