

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 ( $\text{Na}^+$ ,  $\text{Cl}^-$ ,  $\text{NO}_3^-$ , ...)
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,  $[\text{H}^+]$ , ...

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?  $\text{Na}^+$

( $\text{H}^+$ ) strong acid? No

( $\text{OH}^-$ ) strong base? YES

(HA or  $\text{BH}^+$ ) weak acid? YES

(B or  $\text{A}^-$ ) 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

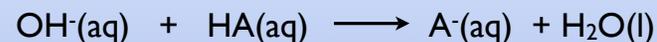
.1L x 1M = 0.1 moles of HA

ICAN .05L x 1M = 0.05 moles of  $\text{OH}^-$

not

ICE

neutralization reaction



init	0.05 moles	0.1 moles	0 moles
change	-0.05 moles	-0.05 moles	+0.05 moles

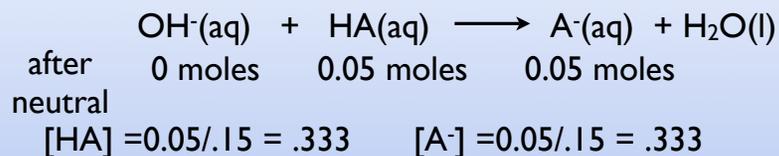
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after	0 moles	0.05 moles	0.05 moles
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neutral

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



What "kind" of solution is this?

buffer

How do I calculate the pH for different solutions?

Strong Acid

$$[\text{H}^+] = C_a$$

Strong Base

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

Weak Acid

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

Weak Base

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

Buffer

$$[\text{H}^+] = K_a C_a / C_b$$

Buffer

$$[\text{OH}^-] = K_b C_b / C_a$$

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?

$$[\text{HA}] = 0.05/.15 = .333 \quad [\text{A}^-] = 0.05/.15 = .333$$

Buffer

$$[\text{H}^+] = K_a C_a / C_b$$

$$\text{pH} = 4$$

Buffer

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

$$\text{pOH} = 10$$

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<sup>-</sup>

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  
 $\text{OH}^- + \text{HA} \rightarrow \text{A}^- + \text{H}_2\text{O}$
- 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  $\text{A}^-$  ←  $.1 \text{ L} \times 1 \text{ M} = .1 \text{ HA}$   
 $.1 \text{ L} \times 1 \text{ M} = .1 \text{ OH}^-$   
note: this would be the equivalence point in a titration
- C. .05 M of HA and .05 M of  $\text{A}^-$
- D. .05 M of  $\text{OH}^-$

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

What "kind" of equilibrium problem is this?

- A. strong acid
- B. weak acid
- C. buffer
- D. weak base ←  $\text{A}^-$  is a weak base  
no HA in solution  
no  $\text{H}^+$   
no  $\text{OH}^-$
- E. strong base

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 ( $\text{A}^-$ )?

- A.  $10^{-5}$
- B.  $10^{-7}$
- C.  $10^{-9}$  ←  $K_b \text{ for } \text{A}^- = K_w / K_a \text{ for HA}$   
 $10^{-14} / 10^{-5} = 10^{-9}$
- D.  $10^{-14}$

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  $> 7$

$$C_b = .1/.2 = 0.5 \text{ M}$$

$$[OH^-] = \sqrt{K_b C_b} = \sqrt{5 \times 10^{-10} \times 10^{-9}} = \sqrt{5 \times 10^{-19}} = 2.23 \times 10^{-5}$$
$$pOH = 4.65 \quad pH = 9.35$$

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  
 $A^- = F^-$

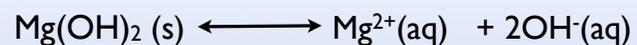
HA and  $A^-$  in the same solution buffer

Let's look at some examples

Roloids® 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 eat 10-20 g NaOH daily just for laughs
- B. Acids are dangerous but bases are quite safe
- C. The saliva in my mouth is acidic enough to "handle it"
- D.  $\text{Mg}(\text{OH})_2$  is not soluble in water

### Solubility Equilibria



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

$\text{OH}^{-}$  that is dissolved neutralizes any  $\text{H}^{+}$   
then more  $\text{OH}^{-}$  dissolves...repeat

end result is a very slightly basic solution