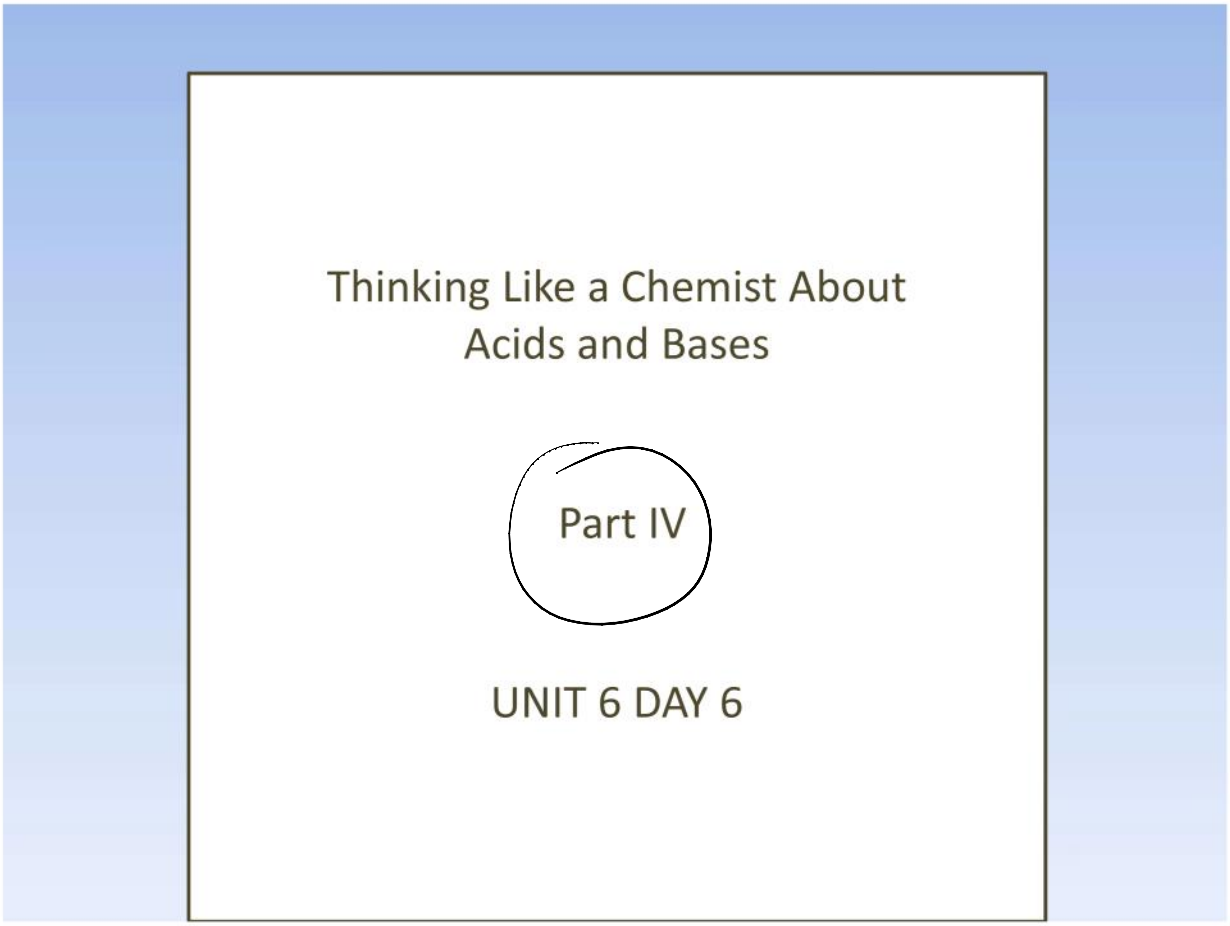
Unit6-Day6-VDB

Tuesday, February 25, 2014
8:34 AM



What are we going to learn today?

Apply the principles of Chemical Equilibrium
to mixtures of Conjugate Acid Base Pairs

Predict the pH of such solutions
Predict the pH of such solutions after stressing the system

Explore the concept of a Buffer solution

IMPORTANT INFORMATION

LM21 - Buffers due Th 9AM

Extra Practice Worksheets on Website

~~Roll~~ Quiz: Clicker Question

pH of salt in water

The pH of a 0.1 M aqueous solutions of the salts $NaCH_3COO$, NH_4Cl, KCl will be:

A) Neutral, Neutral, Neutral
B) Basic, Acidic, Neutral
C) Acidic, Neutral, Basic
D) Basic, Neutral, Acidic
E) Acidic, Basic, Neutral

Quiz: Clicker Question

Calculate the pH of the following solution, 0.15 M HF; given the Ka = 7.2 X 10^{-4}

A) 2.0

B) 4.0

C) 7.0

D) 9.0

E) 12.0

Quiz: Clicker Question

Calculate the pH of the following solution, 0.15 M NaF, given the Ka of HF = 7.2×10^{-4}

A) 2.0

B) 5.9

C) 7.0

D) 8.1

E) 12.0

Na^+ H_2O

F^- H_2O

$\longrightarrow$

$F^- + H_2O \rightleftharpoons HF + OH^-$

$$K_{b\,F^-} = \frac{K_w}{K_a}$$

$$K_b = \frac{[HF][OH^-]}{[F^-]}$$

.15

$[OH]$

IN HEAD

What is in Water?

ACID + BASE → WATER + SALT

ACID + BASE → SALT

? pH

WEAK

$K_a = [H_3O^+][A^-]/[HA]$

or

STRONG

$[acid] = [H_3O^+]$

WEAK

$K_b = [OH^-][BH^+]/[B]$

or

STRONG

$[base] = [OH^-]$

$K_a = [H_3O^+][A^-]/[HA]$

or

$K_b = [OH^-][BH^+]/[B]$

or

Neutral

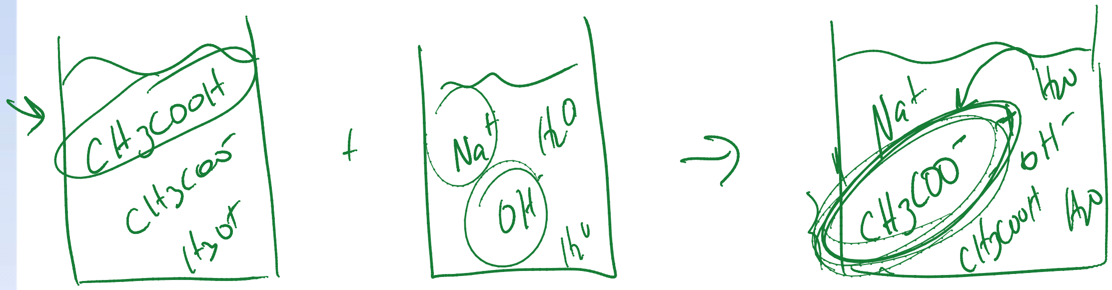
What are the components?

WEAK ACID STRONG BASE

$CH_3COOH\ (aq) + NaOH(aq) \rightarrow NaCH_3COO\ (aq) + H_2O\ (l)$

What are the major species in solution as a result of mixing:

$$100\ \text{mL}\ 0.1\ \text{M}\ CH_3COOH + 100\ \text{mL}\ 0.1\ \text{M}\ NaOH$$



What are the components?

$CH_3COOH\ (aq) + NaOH(aq) \rightarrow NaCH_3COO\ (aq) + H_2O\ (l)$

What are the major species in solution as a result of mixing:

xcess

100 mL 0.1 M $\cancel{CH_3COOH}$ + 200 mL 0.1 M NaOH

CH_3COOH + Na^+ OH^- → CH_3COO^- OH^- →

$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$

pH?

EASY

What are the components?

$CH_3COOH\ (aq) + NaOH(aq) \rightarrow NaCH_3COO\ (aq) + H_2O\ (l)$

What are the major species in solution as a result of mixing:

200 mL 0.1 M CH_3COOH + 100 mL 0.1 ~~M~~ NaOH

CH_3COOH + Na OH^- → CH_3COO^- CH_3COOH

? pH

200 mL .1 M CH_3COOH 100 mL .1 M NaOH

How would you determine the pH?

acetic acid $K_a = 1.8 \times 10^{-5}$

Neutralization Reaction

Convert to moles to determine amounts

R	CH_3COOH	+ NaOH →	$NaCH_3COO$	+ H_2O
I	.02 mol	.01 mol	–	–
C	–.01 mol	–.01 mol	+.01 mol	–
END	.01 mol	∅	.01 mol	–

CONVERT TO CONCENTRATIONS $\frac{.01 \text{ mol}}{.3 L} = .033$ Molar

$K_a = 1.8 \times 10^{-5}$

NOW DO THE EQUILIBRIUM

R	CH_3COOH	+ H_2O ⇌	CH_3COO^-	+ H_3O^+
I	.033	-	.033	–
C	–x		+x	+x
E	.033–x		.033+x	x

$K_a = \frac{[\cancel{CH_3COO^-}][H_3O^+]}{[\cancel{CH_3COOH}]}$

What is pH?

$pK_a = -\log K_a$ $K_a = [H_3O^+] = 1.8 \times 10^{-5}$ pH = 4.74

pH = pKa

Common Ion Effect

The % of ionization is suppressed in the presence of a common ion....Le Chatelier's Principle

? % ionization
0.1 M CH_3COOH

pH = 2.87

? % ionization
0.1 M CH_3COOH solution containing 0.1 M $NaCH_3COO$

pH = 4.74

Poll: Clicker Question

Fully describe:
Weak Base + Strong Acid
reaction with resulting salt solution

$K_b = 1.8 \times 10^{-5}$

Write the chemical reaction and calculate the pH when a 200 mL 0.1 M solution of ammonia is mixed with a 100 mL 0.1 M solution of hydrochloric acid. (This is an example of what you should have mastered by now. If not, take this problem to TA or UGLA office hours.)

$NH_3 + HCl \rightarrow NH_4Cl$

K_b for NH_3 = 1.8×10^{-5}

NH_3

NH_4^+

Before you do the calculation you should be able to predict if the resulting solution would be:

A) Neutral B) Basic C)Acidic

$$K_b = \frac{[\ x\ ]}{[\ \ ]}$$

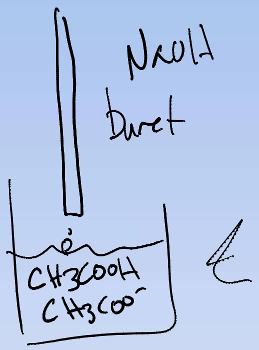
Look at a DEMO

Add a little NaOH to pure water and see what happens!

Add a little NaOH to a 1:1 mixture of acetic acid and sodium acetate and see what happens!

What is the difference?

Write down the neutralization reaction for the demo



$$NaOH + CH_3COOH \rightarrow NaCH_3COO + H_2O$$

CH_3COO^-

$$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H_3O^+$$

OH^- $\longrightarrow$

$+H_3O^+$ $\longleftarrow$

K_a

Because the pH changed very little it is called a buffer solution.

Buffer- a solution in which the pH resists change when a strong acid or base is added

Buffers can be acidic

Buffers can be basic

Because the pH changed very little it is called a buffer solution.

What happens if we keep adding NaOH to the solution.....

Calculate the pH of buffer solution

- 1 mole CH_3COOH and 1 mole $NaCH_3COO$ in 1 L solution.

1M 1M

$1+x$

$$1.8 \times 10^{-5} = K_a = \frac{[CH_3COO^-][H_3O^+]}{[CH_3COOH]}$$

$1-x$

$$-\log\left([H_3O^+] = 1.8 \times 10^{-5}\right)$$

4.74

Derive a shortcut formula

$$-\log\left(K_a = \frac{[A^-]_{eq}[H_3O^+]_{eq}}{[HA]_{eq}}\right)$$

$[A^-]_{eq} = [A^-]_0$

$[HA]_{eq} = [HA]_0$

$$-\log K_a = -\log\frac{[A^-]}{[HA]} - \log[H_3O^+]$$

$$pK_a = -\log\frac{[A^-]}{[HA]} + pH$$

$$pH = pK_a + \log\frac{[A^-]_0}{[HA]_0}$$

Henderson-Hasselbach

initial conjugate base

initial weak acid

When the initial acid and base are similar in concentration then the pH is close to the pKa

For the pH to be 1 unit different than the pKa the difference in concentrations must be at least 10 X!

difference in concentrations must be at least 10 X!

Poll: Clicker Question

The pK_a of HF is 3.18. What is the pH of solution of 100 mL of 0.1 M HF and 100 mL of a 0.2 M NaF?

A. slightly less than 3.18
B. 3.18
C. slightly more than 3.18

Calculate the pH of a buffer system

Calculate the pH of a buffer solution that is 0.15 M $HNO_2(aq)$ and 0.2 M $NaNO_2(aq)$.

Calculate pH using Henderson-Hasselbach

Calculate the pH of a buffer solution that is 0.015 M $HNO_2(aq)$ and 0.02 M $NaNO_2(aq)$.

Compare the two solutions

$0.15\ M\ HNO_2(aq)$
$0.2\ M\ NaNO_2\ (aq)$
pH = 3.94

$0.015\ M\ HNO_2(aq)$
$0.02\ M\ NaNO_2\ (aq)$
pH = 3.94

Any important differences between the two?

Select buffer composition for desired pH

Calculate the ratio of the molarities of acetate ion to acetic acid needed to buffer a solution at pH=5.25. The pK_a of CH_3COOH is 4.75.

- You have a buffer solution containing acetic acid and acetate ion. You add adjust the pH to be 3.75. Which is present in the higher concentration: the protonated or deprotonated molecule?

What did we learn today?

Weak acids or bases have limited ionization in the presence of a common ion.

Substantial amounts of conjugate acid base pairs, together in solution resist change in pH.

- This effect is called buffering.
- When [HA] = [A^-], the pKa = pH of that solution.
- When [B] = [BH^+], the pKb = pOH of that solution.

Learning Outcomes

Understand the concept of a buffer, buffer capacity and buffering range.

Calculate the pH of a buffer solution.
Show mastery of the Henderson-Hasselbalch equation

Calculate the pH of a buffer solution after the addition of a strong acid or strong base.

Calculate the pH change of a buffered solution

- Suppose that 0.0200 mol NaOH(s) is dissolved in 300 mL of the following buffer solution: 0.040 M $NaCH_3CO_2$(aq) and 0.080 M CH_3COOH(aq). What is the final pH of the solution?