UNIT6-DAY4-LaB1230pm

Monday, February 18, 2013
2:28 PM

Thinking Like a Chemist
About Acids and Bases
Part II

UNIT6 DAY4

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What are we going to learn today?

Thinking Like a Chemist in the
Context of the Chemical Equilibrium
Acids and Bases

Conjugate Acid Base Pairs
Acid/Base Strength
Auto-ionization of Water
pH and pOH

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IMPORTANT INFORMATION

LM19 K_a, K_b & K_w due Th 9 AM
LM20 pH & pOH due Th 9 AM

Extra Practice Worksheets on Website

NGLM 101 - Exam Wrapper

Bonus Pts (on participation)

Quiz Clicker Question 1

1. Which of the following is not a strong acid?

A) HF
B) HCl
C) HBr
D) HI
E) $HClO_4$

Quiz Clicker Question 2

2. Which of the following is not a strong base?

A) NaOH
B) RbOH
C) $Sr(OH)_2$
D) $Mg(OH)_2$ not soluble in H_2O

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Quiz Clicker Question 3

3. Which of the following is not a correctly matched set?

memorize this too!

A) Ammonia, NH_3
B) Perchloric Acid, $HClO_3$ $HClO_4$
C) Nitric Acid, HNO_3
D) Sulfuric Acid, H_2SO_4
E) Hydrobromic Acid, HBr

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Dumped From Brain Prior Acid-Base Knowledge

Demo Review –
HCl and CH_3COOH solutions both turned yellow when indicator was added. Very different chemical structures, but same effect on indicator. Why?

Action in Solution

Acid is PROTON donor → $[H_3O^+]$ → common to all acidic solutions

Base is PROTON acceptor

↳ $[OH^-]$ → Common to all basic solutions

Quiz Clicker Question 4

Which reactant is behaving like a base in the following reaction?

$CN^-(aq) + H_2O(l) \leftrightarrow HCN(aq) + OH^-(aq)$

Result

Base is a proton acceptor

A) OH^-
B) HCN
C) H_2O
D) CN^-

Quiz Clicker Question 5

What is the conjugate base of HCOOH?
What is the conjugate acid of HPO_4^{2-}?

A) $HCOO^-$, PO_4^{3-}

What is the conjugate base of HCOOH?

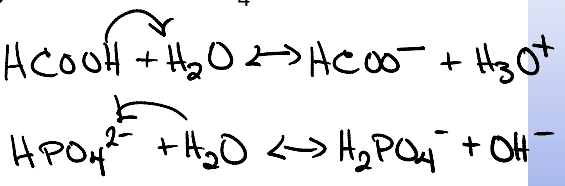
What is the conjugate acid of HPO_4^{2-}?

A) $HCOO^-$, PO_4^{3-}

B) $COOH$, PO_4^{3-}

C) $HCOO^-$, $H_2PO_4^{1-}$

D) $HCOOH_2^+$, H_3PO_4



REVIEW

Brønsted-Lowry Acid-Base-Conjugate Partners

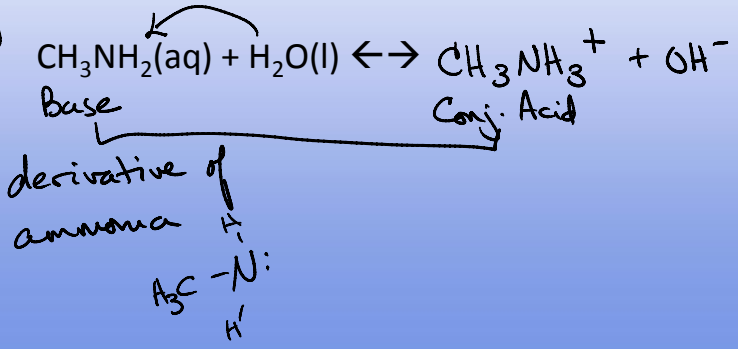
1st label reactants as acid or base

2nd label products as conjugate acid or base

Can you finish this reaction and label conjugate acid/base pairs?

NH_3 ammonia (weak base)

Identify acid & base



Do Part I of Activity Sheet

Do Part I of Activity Sheet

Which of the following can act as a base?

A)I

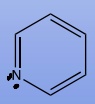
B)I & II

C)I, II & III

D)I & III

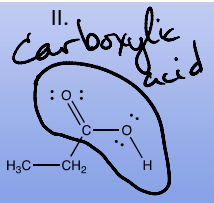
E)II & III

I.



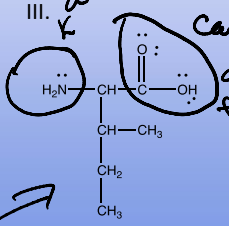
pyridine

II. carboxylic acid



III. amine functional group

carboxylic acid functional group



amino acid isoleucine

Take a Look at Part II on Activity Sheet

Part II on Activity Sheet

The acids in the first data table are listed:
A)In order of increasing acid strength
B)In order of decreasing acid strength
C)There is no way to say because pH's are not listed
D)There is no way to say because pKa's are not listed

Table I - acids

Conjugate Acid-Base Pairs

After examining the Ka and Kb data in the two data tables, the inferred relationship between the strengths of acids and their conjugate partners is:

A)Strong acids have strong conjugate base partners
B)The stronger the acid, the weaker the conjugate base partner
C)This is nonsense as pH's are not given

Take a Look at Part II on Activity Sheet

$H_2O(l) + H_2O(l) \leftrightarrow H_3O^+ + OH^-$

The equilibrium expression for water is:

A) $K_w = [H_3O^+][OH^-]/[H_2O]^2$ 1

B) $K_w = [H_3O^+][OH^-]/[H_2O]$ 1

C) $K_w = [H_3O^+][OH^-]$

Take a Look at Part II on Activity Sheet

$HClO_2(aq) + H_2O(l) \leftrightarrow ClO_2^- + H_3O^+$ $\quad K_a = \frac{[ClO_2^-][H_3O^+]}{[HClO_2]}$

$+ \; ClO_2^-(aq) + H_2O(l) \leftrightarrow HClO_2 + OH^-$ $\quad K_b = \frac{[HClO_2][OH^-]}{[ClO_2^-]}$

$+ ClO_2^-(aq) + H_2O(l) \leftrightarrow HClO_2 + OH^-$ $\quad K_b = \frac{[HClO_2][OH^-]}{[ClO_2^-]}$

$H_2O + H_2O \leftrightarrow H_3O^+ + OH^-$

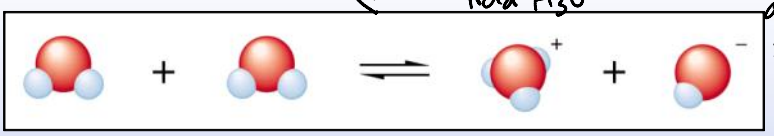
K_a K_b

$K_w = (1.2\times10^{-2})(8.3\times10^{-13}) = 1\times10^{-14}$ (from table)

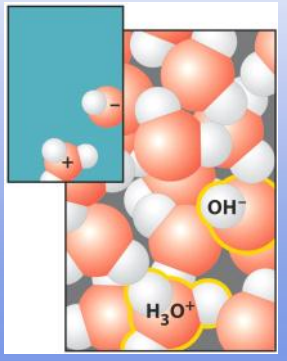
$K_a \cdot K_b = \frac{[ClO_2^-][H_3O^+]}{[HClO_2]} \times \frac{[HClO_2][OH^-]}{[ClO_2^-]} = [H_3O^+][OH^-]$

$K_w = [H_3O^+][OH^-] = 1\times10^{-14}$

Auto-ionization of Water



$K_w = [H_3O^+][OH^-] = 1X10^{-14}$



- Pure water always has some hydronium and hydroxide present.
- Equal amounts – neutral
- More hydronium – acidic
- More hydroxide – basic

Calculate $[H_3O^+]$ and $[OH^-]$

#1: What is HI? Strong acid

Determine the $[H_3O^+]$ & $[OH^-]$ at 25ºC in 6.0×10^{-2} M HI(aq)

$HI + H_2O \rightarrow H_3O^+ + I^-$

$[H_3O^+] = 6.0\times10^{-2}$ M (strong acid, ionizes 100%)

$[OH^-] = ?$

$K_w = [H_3O^+][OH^-]$

$1\times10^{-14} = (6.0\times10^{-2})[OH^-]$

use water equilibrium to calculate $[OH^-]$

$1 \times 10^{-14} = (6.0 \times 10^{-2})[OH^-]$ to U calc

$1.7 \times 10^{-13} = [OH^-]$

Calculate $[H_3O^+]$ and $[OH^-]$

NH_3 weak base

NH_4^+ conj acid

$K_a \cdot K_b = 1 \times 10^{-14}$

what's this? weak...

Determine the $[H_3O^+]$ & $[OH^-]$ in 6.0×10^{-2} M NH_4^+(aq)

Some bases are weaker than others ⇒ look at values

degree of strength of acids ⇒ K_a

R	$NH_4^+ + H_2O \leftrightarrow$	NH_3	$+ H_3O^+$
I	6.0×10^{-2}	0	0
C	$-x$	$+x$	$+x$
E	$6.0 \times 10^{-2} - x$	x	x

$K_a = \frac{[NH_3][H_3O^+]}{[NH_4^+]}$

$K_a = \frac{x \cdot x}{6.0 \times 10^{-2} - x}$

$5.6 \times 10^{-10} \cong \frac{x^2}{6.0 \times 10^{-2}}$

$x = 5.8 \times 10^{-6} = [H_3O^+]$

$K_w = [H_3O^+][OH^-]$

$1 \times 10^{-14} = (5.8 \times 10^{-6})[OH^-]$

$[OH^-] = 1.7 \times 10^{-9}$

Conjugate Acid-Base Pairs

$CH_3COOH(aq) + H_2O(l) \leftrightarrow CH_3COO^-(aq) + H_3O^+(aq)$

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

$CH_3COO^-(aq) + H_2O(l) \leftrightarrow CH_3COOH(aq) + OH^-(aq)$

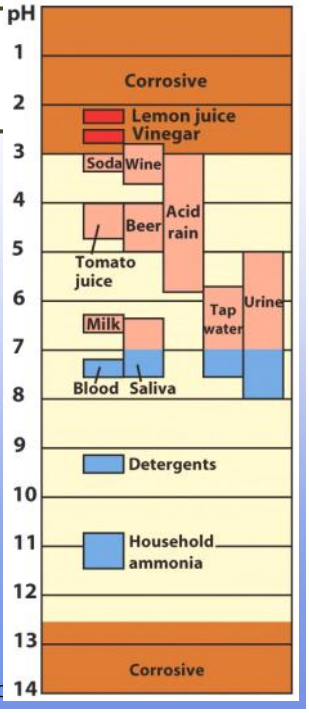
$K_b = ?$

Express degree of acidity using pH and degree of basicity using pOH

- pH = -log[H_3O^+]
  ↳ easier number!
- Calculate the pH of 6X10^{-5} M $HClO_4$?
  $[H_3O^+] = 6 \times 10^{-5}$
  $pH = 4.2$
  ↳ strong acid 100%
- Calculate the ~~pH~~ pOH of .077 M NaOH.
  $pOH = -\log[OH^-]$
  $= -\log(0.077)$
  $pOH = 1.1$
  ↳ strong base 100%

$[H_3O^+] > [OH^-]$ acidic

$[OH^-] > [H_3O^+]$ basic



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Calculate the [H_3O^+] from the pH

- Find the [H_3O^+] in a solution with a pH = 4.83.

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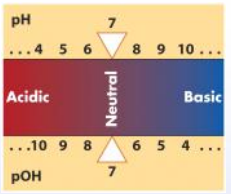
Calculate the $[H_3O^+]$ from the pH



$K_w = [H_3O^+][OH^-]$

Take log of both sides of equation:

Calculate pOH and $[OH^-]$ in a solution with a pH=4.83.

Calculate the K_a of a weak acid.

The pH of a .2 M aqueous solution of crotonic acid is 2.69. What is the K_a of crotonic acid?

Calculate the pH of a weak base solution.

Calculate the pH of a .15 M $NH_2OH(aq)$ solution

What did we learn today?

The strengths of conjugate acid base pairs is coupled via K_w : $K_w = [H_3O^+][OH^-] = 1 \times 10^{-14}$

Strong acid – Very Weak Conjugate Base
Strong base – Very Weak Conjugate Acid

Determine pH and pOH of various solutions.

Learning Outcomes

Convert between hydronium ion concentration, hydroxide ion concentration, pH and pOH for a given solution

Determine the pH of a strong acid or base solution

Determine the pH of a weak acid or base solution

Apply concepts from equilibrium to acid/base problems