
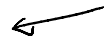


Thinking Like a Chemist
About Acids and Bases
Part II


UNIT 6 DAY 4

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 

IMPORTANT INFORMATION

LM18 K_a , K_b & K_w due Th 9 AM

LM19 pH & pOH due Th 9 AM

Extra Practice Worksheets on Website

Lunch @ J2
12-1

Individual Quiz Clicker Question; NO TALKING



Which of the following is not a strong acid?

A) HF

B) HCl

C) HBr

D) HI

E) HClO₄



Individual Quiz Clicker Question; NO TALKING

Which of the following is not a strong base?

A) NaOH

B) RbOH

C) $\text{Sr}(\text{OH})_2$

D) $\text{Mg}(\text{OH})_2$

Quiz Clicker Question

Which of the following is not a correctly matched set?

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



Prior Acid-Base Knowledge

Demo Review:

1. What happened when indicator was added to HCl and CH_3COOH solutions?

~~FEW IONS.~~

LOTS IONS
STRENGTH

Very different chemical structures, but same effect on indicator. Why?

2. Did solutions seem as similar when we tested their conductivity with the light bulb?

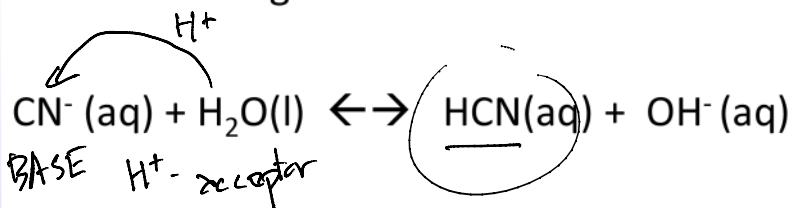
HCl → Bright

LOT IONS

STRONG ACID

Quiz Clicker Question

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



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

Quiz Clicker Question

What is the conjugate base of HCOOH?

← TAKE OFF H^+

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

← ADD H^+

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

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

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

D) $HCOOH_2^+$, H_3PO_4



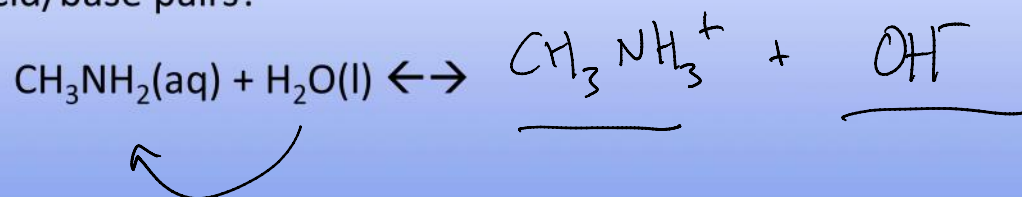
Having problems? Write the reactions for each of these interacting with water.

REVIEW: Bronsted-Lowry Acid-Base-Conjugate Partners

1st label reactants as acid or base

Then label products as conjugate acid or base

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



Do Part I of Activity Sheet

Hydro H^+ + ion (Cl^- , ClO^- , F^- ,)

Oxy HNO_3 , HNO_2 ,

carboxylic acid $R-COOH$

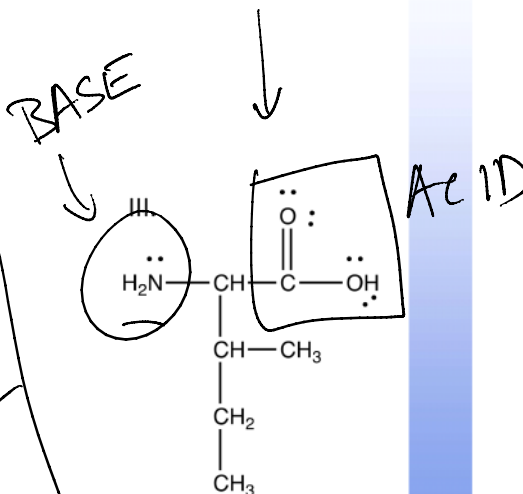
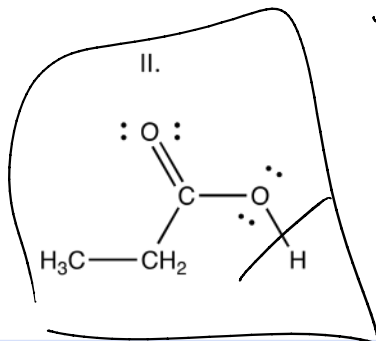
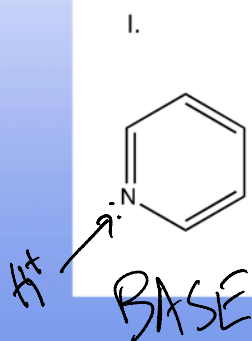
Amine Ammonia derivatives

Metal Hydroxid $M^+ OH^-$

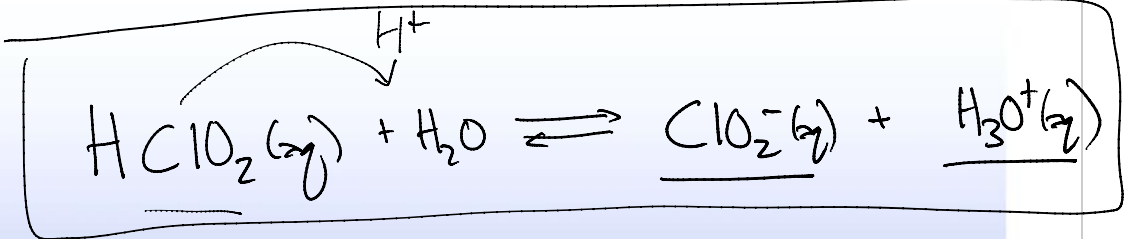
Polling Clicker Question

Which of the following can act as a base?

- A) I
- B) I & II
- C) I, II & III
- D) I & III
- E) II & III



Take a Look at Part II on Activity Sheet



$$K_a = \frac{[\text{ClO}_2^-][\text{H}_3\text{O}^+]}{[\text{HClO}_2]} = \frac{\text{PROD}}{\text{REACT}}$$

"DISSOCIATED"
"undissociated"

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

Polling Clicker Question

Conjugate Acid-Base Pairs

After examining the K_a and K_b 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

Polling Clicker Question

Part II on Activity Sheet

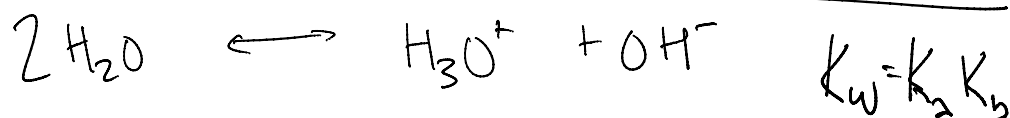
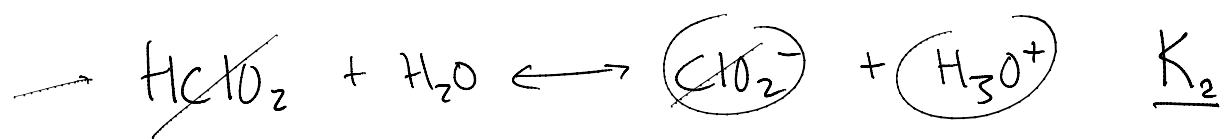
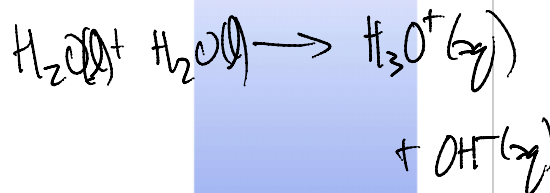
The equilibrium expression for water is:

A) $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]/[\text{H}_2\text{O}]^2$

B) $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]/[\text{H}_2\text{O}]$

C) $K_w = [\text{H}_3\text{O}^+][\text{OH}^-]$

↑
↑
CONST

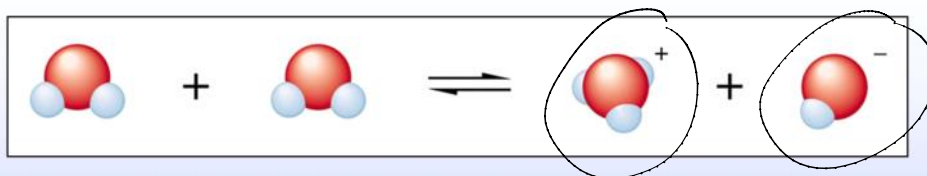


$$\frac{[\text{ClO}_2^-][\text{H}_3\text{O}^+]}{[\text{HClO}_2]} \times \frac{[\text{HClO}_2][\text{OH}^-]}{[\text{ClO}_2^-]} = [\text{H}_3\text{O}^+][\text{OH}^-] = K_w$$

Take a Look at Part II on Activity Sheet

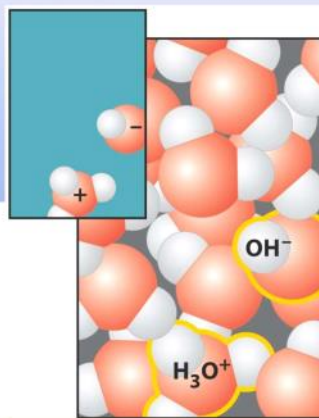


Auto-ionization of Water



$$K_w = [\text{H}_3\text{O}^+][\text{OH}^-] = 1 \times 10^{-14}$$

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



$$K_w = K_a K_b$$

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

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

$$[OH^-] = ?$$

$$[H_3O^+] = 10^{-2} \text{ M}$$

$$[OH^-] = \frac{K_w}{[H_3O^+]} = \frac{10^{-14}}{10^{-2}} = \underline{\underline{10^{-12} \text{ M}}}$$

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

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

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

WEAK ACID

✓ $[OH^-] = ?$

K_2

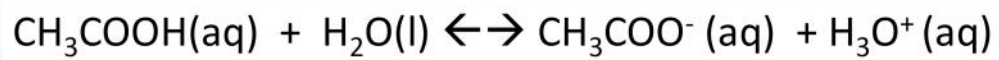
RICE

solve $[H_3O^+]$

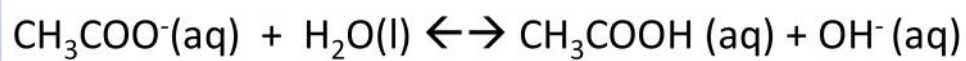
↓ K_w

$[OH^-]$

Conjugate Acid-Base Pairs



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



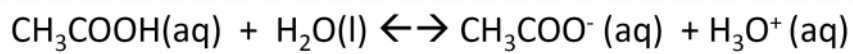
$$K_b = ?$$

Conjugate Acid-Base Pairs

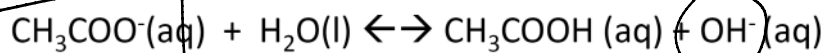
$$K_a \times K_b = K_w$$

10^{-14}

10^{-5}



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



$$K_b = ?$$

A. $\sim 10^{-9}$

B. $\sim 10^{-19}$

C. $\sim 10^{-14}$

D. $\sim 10^{-3}$

$$K_b = \frac{K_w}{K_a}$$

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

$$\text{pH} = -\log[\text{H}_3\text{O}^+]$$

$$\text{pOH} = -\log[\text{OH}^-]$$

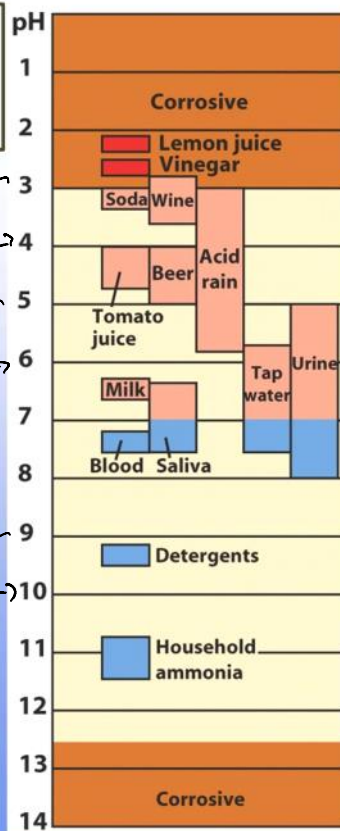
- Calculate the pH of $6 \times 10^{-5} \text{ M HClO}_4$.

- What is the relationship between pH and pOH?

$$\log(10^{-4}) = -4$$

$$\log(10^{-2}) = -2$$

- Calculate the pH of $.077 \text{ M NaOH}$.



$$\rightarrow [\text{H}_3\text{O}^+] = 6 \times 10^{-5} \text{ M} \quad \text{pH} = -\log(6 \times 10^{-5}) = 4.22$$

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



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

$$pH = -\log([H_3O^+])$$

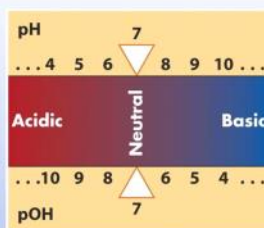
$$[H_3O^+] = 10^{-(pH)}$$

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

$$\log(10^{-14}) = \log[H_3O^+] + \log[OH^-]$$

$$14 = pH + pOH$$

Calculating the ion concentrations from the pH



What can you tell us about a solution with a pH=4.83?

Calculate the K_a of a weak acid.

The pH of a 0.2 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 $\text{NH}_2\text{OH}(\text{aq})$ solution.

$$K_b = 1.1 \times 10^{-8}$$

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