UNIT6-DAY3-LaB1230

Thursday, February 14, 2013
8:17 AM

Thinking Like a
Chemist About
Acids and Bases

UNIT 6 DAY3

CH302 Vanden Bout/LaBrake Spring 2013

What are we going to learn today?

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

Dredge up what you know about acids/bases
Weak Acids/Weak Bases vs Strong Acids/Bases
Behavior of these compounds in water

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IMPORTANT INFORMATION

LM18 Strong Acids & Bases due Tue 9 AM
LM19 Weak Acids & Bases due Tue 9 AM
HW5 due Tue 9 AM
long, but simple, but long
UG - OFFICE HOURS FRIDAY 1-3PM!!
one-on-one time
GSB 2.126

Lunch @ Jester City Limits Monday 12:30

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Quiz Clicker Question 1

The following reaction is at equilibrium:

$C(s) + 2Cl_2(g) \leftrightarrow CCl_4(g) + \text{energy}$

The reaction will shift (left/right/not shift) when I add C(s). The reaction will shift (left/right/not shift) when I increase the temperature.

A) LEFT ; LEFT

B) RIGHT ; LEFT

C) NOT SHIFT ; NOT SHIFT

D) NOT SHIFT ; LEFT

Adding or taking away solids/liquids does not affect equilibrium
depends on mass action

↑CCl_4 left
↑ Cl_2 right

↓Vol right
(fewer gas moles)

↓ Pressure
(have to ↑V)
goes to more gas moles

Does NOT participate in the chemistry of reaction
Inert Gas

Constant Volume
- container is the same
- total P ↑
- Partial Press are the same
⇒ no change

Constant Pressure
- to keep P const. Volume must change
V ↑
→ same result as Vol inc.
shift to more gas moles

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Quiz Clicker Question 2

What is the concentration of CH_3COO^- in a 0.2 M aqueous solution of CH_3COOH at equilibrium?

A. 0.2 M

B. 0.4 M

C. 1.89×10^{-3} M

D. 1.98×10^{-6} M

A) just me

B) w/ others

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- Assume starting concentration of 0.2 M acetic acid. Calculate concentrations of all species at equilibrium. Ka = 1.8×10^{-5}

↳ acid

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

pure liquid

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

$1.8 \times 10^{-5} = \frac{(x)(x)}{0.2 - x}$ $\qquad$ $1.8 \times 10^{-5} = \frac{x^2}{0.2}$

$\sqrt{(0.2)(1.8 \times 10^{-5})} = \sqrt{x^2}$

Initial	0.2	∅	∅
+ Change	$-x$	$+x$	$+x$
Equilibrium	$0.2-x$	x	x

Principles of Chemistry II $\qquad$ © Vanden Bout

approximate and ignore x

assume x will be really small and negligible

WHEN CAN WE IGNORE IT?!

If $K < 1 \times 10^{-3}$

ignore x in change for starting material

Quiz Clicker Question 3

Poll

Assume that we can increase the concentration of the hydronium ion, (H_3O^+). What will happen to the concentration of the CH_3COOH (acetic acid)? $CH_3COOH + H_2O \leftrightarrow CH_3COO^- + H_3O^+$

inc $\qquad$ ← shifts left $\qquad$ ↑ add

A) Increase

B) Decrease

C) Stay the same

#2) What about CH_3COO^-?

decreases

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Quiz Clicker Question 4 & 5

Poll

4) What is the assumed concentration HCl in a 0.2 M aqueous solution of HCl at equilibrium?

A) 0.2 M

B) 0.1 M

C) 0.4 M

D) 0.0 M

↳ strong acid

$HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

5) What is the assumed concentration of the hydronium ion in a 0.2 M aqueous solution of HCl at equilibrium?

A) 0.2 M

B) 0.1 M

C) 0.4 M

D) 0.0 M

goes to completion

Assume 100% ionization forming ions

What is the assumed concentration of the hydronium ion in a 0.2 M aqueous solution of HCl at equilibrium?

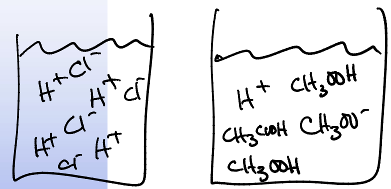
A) 0.2 M
B) 0.1 M
C) 0.4 M
D) 0.0 M

Assume 100% ionization
forming ions
Assume 100% dissociation

acidity indicator

BTB indicator in acidic, neutral, and alkaline solutions (left to right).

Electrolytes



Brain Dump Acids and Bases

Acids

- proton donor
- sour
- litmus → red
- strong acids dis. 100%
- acids have low pH
- 7 strong acids
- conduct electricity in H_2O
- weak acid, strong conj base pr.
- acids react w/ active metals

Bases

- slippery
- bitter
- litmus → blue
- 8 strong bases
- pH is > 7, up to 14
- conduct electricity in water
- proton acceptors
- strong bases diss 100%
- have conjugate acid pr.

Brain Dump Acids and Bases

We'll use the Bronsted Lowry definition

Acid is PROTON donor

Base is PROTON acceptor

$$\underset{\text{acid}}{CH_3COOH} + \underset{\text{base}}{H_2O} \longleftrightarrow \underset{\text{conj. base}}{CH_3COO^-} + \underset{\text{conj. acid}}{H_3O^+}$$

$$HCl + H_2O \rightarrow Cl^- + H_3O^+$$

Base is PROTON acceptor

$NH_3 + H_2O \leftrightarrow NH_4^+ + OH^-$
base acid Conj acid Conj base

$CH_3COO^- + H_2O \leftrightarrow CH_3COOH + OH^-$
base acid

Strength Depends on Extent of Ionization

"Strong" means one thing
The substance dissociates 100% in water

Strong Acid

$HCl(aq) \rightarrow H^+(aq) + Cl^-(aq)$

$K_a =$

Strong Electrolyte

$NaCl(s) \rightarrow Na^+(aq) + Cl^-(aq)$

$K_{sp} =$

Strong Base

$NaOH(s) \rightarrow Na^+(aq) + OH^-(aq)$

MEMORIZE STRONG ACIDS

Hydrochloric

Hydrobromic

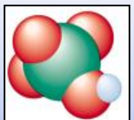
Hydroiodic

Perchloric

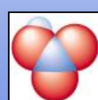
Chloric

Sulfuric

Nitric

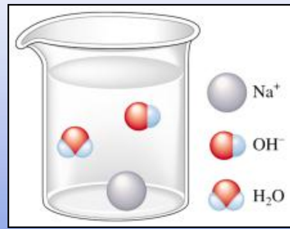

Perchloric acid ($HClO_4$)


Sulfuric acid (H_2SO_4)


Nitric acid (HNO_3)

MEMORIZE STRONG BASES
Group IA Hydroxides & some Group IIA Hydroxides

- $LiOH$
- $NaOH$
- KOH
- $RbOH$
- $CsOH$
- $Ca(OH)_2$
- $Sr(OH)_2$
- $Ba(OH)_2$



Strength Depends on Extent of Ionization

"WEAK" means one thing
The substance IONIZES to a limited extent in water

Weak Acid

$HClO(aq) + H_2O(l) \rightarrow H^+(aq) + ClO^-(aq)$ $K_a =$

Weak Base

$NH_3(aq) + H_2O(l) \rightarrow NH_4^+(aq) + OH^-(aq)$ $K_b =$

RECOGNIZE WEAK ACIDS
Often Carboxylic Acids or some OxyAcids

Acetic Acid
Formic Acid
Benzoic Acid

Nitrous Acid
Chlorous Acid
Hypochlorous Acid

Hydroflouric Acid
Hydrocyanic Acid

RECOGNIZE WEAK BASES
Derivatives of Ammonia

Base
ammonia, NH_3
trimethylamine, $(CH_3)_3N$
methylamine, CH_3NH_2
dimethylamine, $(CH_3)_2NH$
ethylamine, $C_2H_5NH_2$
triethylamine, $(C_2H_5)_3N$
hydrazine, NH_2NH_2

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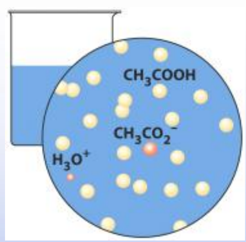
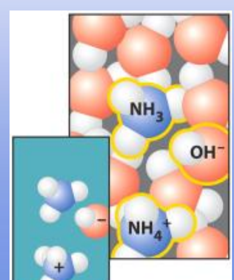
Brønsted-Lowry Definition

Acid is PROTON donor



Base is PROTON acceptor



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Brønsted-Lowry Acid-Base-Conjugate Partners

1st label reactants as acid or base
2nd label products as conjugate acid or base

$HCN(aq) + H_2O(l) \leftrightarrow CN^-(aq) + H_3O^+(aq)$

What is the conjugate acid of OH^-?

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

What did we learn today?

Acid is Proton Donor
Acid is considered strong or weak
Base is a Proton Acceptor
Base is considered strong or weak

The extent of ionization is described by the equilibrium constant, K.

Must memorize common strong acids and bases, and recognize common weak acids and bases.