Chem 108: Class/ Lab
Week 11

Pick a vial and a plastic dropper
Using the vial number, sign-in on the Lab roster

TODAY:
1) Fluid Exchange
(Handout) *Due Next Lab*
2) Acid-Base Equilibrium Experiment
(Handout)
Due & signed Today

DUE & To Do Today

Chem 108: Lab
Week 11


Lab:
Discussion, Experiments & Graded Assignments:

- Week #11 Powerpoint .html, .ppt, Print: .pdf (6 slides per page)

(GQ) Viewing: *Solutions & Concentrations Guiding Questions*
Laboratory Manual *Seven Solution Problem* Report Form pp. 76-80; DUE Today
POST LAB Questions DUE Today


Experimentation:

Doing:

- (GQ) Viewing: *Acids-Bases pH* Guiding Questions
- Fluid Exchange/ Fluid Exchange Form DUE 1-Nov
- Household Acids & Bases / pH: *Experiment & Report Form DUE 1-Nov*

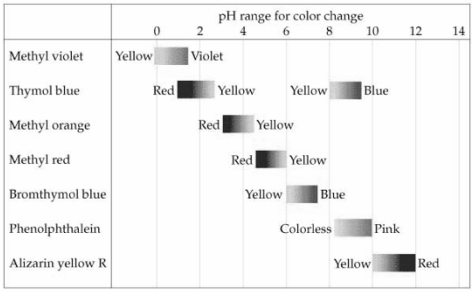
Chem 108: Class/ Lab
Week 11

Follow Instructions
http://chemconnections.org/general/chem120/fluid-ex.108.html

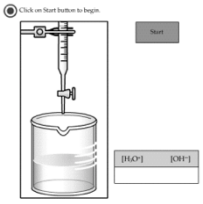
Acid-Base Indicators

Indicators

Acid-Base Indicators



Water as an Acid and a Base
Self-ionization



http://chemconnections.org/general/movies/KwActivity.swf

Water is neutral
It is an Acid and a Base

$$H_2O(l) + H_2O(l) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

What is equilibrium?

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

		conj acid 2	conj base 1
acid 1	base 2		

- $K_w = 1 \times 10^{-14}$ at 25°C
- $K_w = [H_3O^+][OH^-] = [1 \times 10^{-7}M][1 \times 10^{-7}M]$

The pH Scale

- $pH \approx -\log[H^+] \approx -\log[H_3O^+]$
- pH in water ranges from 0 to 14.
  $K_w = 1.00 \times 10^{-14} = [H^+]\,[OH^-]$
  $pK_w = 14.00 = pH + pOH$
- As pH rises, pOH falls (sum = 14.00).
- There are no theoretical limits on the values of pH or pOH. (e.g. pH of 2.0 M HCl is -0.301)

https://phet.colorado.edu/en/simulation/ph-scale-basics

Acid-Base Strengths
pH [indicator paper & pH meter]

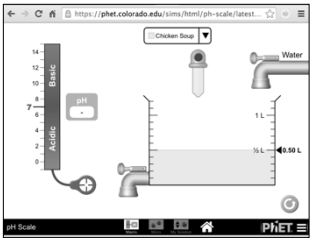
https://phet.colorado.edu/en/simulation/ph-scale

Strong Acid:

Strong Base:

Weak Acid:

Weak Base:



http://www.chemconnections.org/general/chem108/Acids-Bases%20Guide.html

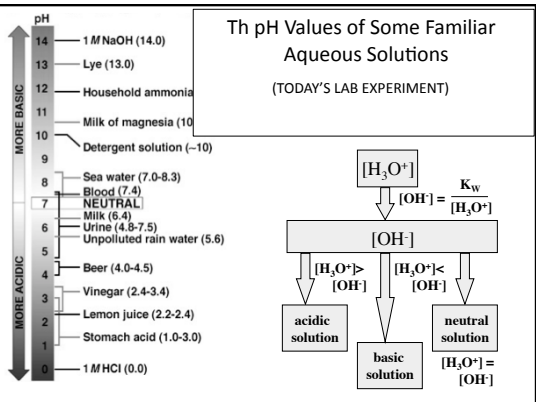
The Relations Among $[H_3O^+]$, pH, $[OH^-]$, and pOH

MORE BASIC ↑ / MORE ACIDIC ↓

	$[H_3O^+]$	pH	$[OH^-]$	pOH
BASIC	1.0×10^{-15}	15.00	1.0×10^{1}	−1.00
	1.0×10^{-14}	14.00	1.0×10^{0}	0.00
	1.0×10^{-13}	13.00	1.0×10^{-1}	1.00
	1.0×10^{-12}	12.00	1.0×10^{-2}	2.00
	1.0×10^{-11}	11.00	1.0×10^{-3}	3.00
	1.0×10^{-10}	10.00	1.0×10^{-4}	4.00
	1.0×10^{-9}	9.00	1.0×10^{-5}	5.00
	1.0×10^{-8}	8.00	1.0×10^{-6}	6.00
NEUTRAL	1.0×10^{-7}	7.00	1.0×10^{-7}	7.00
ACIDIC	1.0×10^{-6}	6.00	1.0×10^{-8}	8.00
	1.0×10^{-5}	5.00	1.0×10^{-9}	9.00
	1.0×10^{-4}	4.00	1.0×10^{-10}	10.00
	1.0×10^{-3}	3.00	1.0×10^{-11}	11.00
	1.0×10^{-2}	2.00	1.0×10^{-12}	12.00
	1.0×10^{-1}	1.00	1.0×10^{-13}	13.00
	1.0×10^{0}	0.00	1.0×10^{-14}	14.00
	1.0×10^{1}	−1.00	1.0×10^{-15}	15.00

Th pH Values of Some Familiar Aqueous Solutions

(TODAY'S LAB EXPERIMENT)



QUESTION

In a solution of water at a particular temperature the $[H^+]$ may be 1.2×10^{-6} M. What is the $[OH^-]$ in the same solution? Is the solution acidic, basic, or neutral?

A. 1.2×10^{-20} M; acidic
B. 1.2×10^{-20} M; basic
C. 8.3×10^{-9} M; basic
D. 8.3×10^{-9} M; acidic

ANSWER

D. correctly shows the OH^- molarity and classifies the solution as acidic. $K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$ at 25°C. The H^+ molarity is approximately 1,000 times greater than the OH^- concentration. Solutions with higher H^+ concentrations than OH^- are acidic.

QUESTION

An environmental chemist obtains a sample of rainwater near a large industrial city. The $[H^+]$ was determined to be 3.5×10^{-6} M. What is the pH, pOH, and $[OH^-]$ of the solution?

A. pH = 5.46 ; pOH = 8.54; $[OH^-] = 7.0 \times 10^{-6}$ M
B. pH = 5.46 ; pOH = 8.54; $[OH^-] = 2.9 \times 10^{-9}$ M
C. pH = 12.56 ; pOH =1.44 ; $[OH^-] = 3.6 \times 10^{-2}$ M
D. pH = 8.54; pOH = 5.46; $[OH^-] = 2.9 \times 10^{-9}$ M

ANSWER

B. provides all three correct responses. The expression $pH = -\log[H^+]$ can be used to find the pH then: 14.00 = pH + pOH can be used to obtain the pOH. Finally, $[OH^-] = 10^{-pOH}$.

The pH Scale

$[H^+]$	$[OH^-]$	pH	pOH	acidic or basic?
$7.5 \times 10^{-3}\ M$				
	$3.6 \times 10^{-10}\ M$			
		8.25		
			5.70	

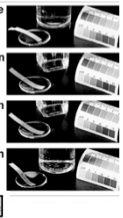
The pH Scale

$[H^+]$	$[OH^-]$	pH	pOH	acidic or basic?
$7.5 \times 10^{-3}\ M$	1.3×10^{-12}	2.1	11.9	Acid
2.8×10^{-5}	$3.6 \times 10^{-10}\ M$	4.6	9.4	Acid
5.62×10^{-9}	1.78×10^{-6}	8.25	5.75	Base
5.00×10^{-9}	2.00×10^{-6}	8.30	5.70	Base

Behavior of Salts in Water

The Behavior of Salts in Water

Salt Solution (Examples)	pH	Nature of Ions	Ion That Reacts with Water
Neutral [NaCl, KBr, $Ba(NO_3)_2$]	7.0	Cation of strong base Anion of strong acid	None
Acidic [NH_4Cl, NH_4NO_3, CH_3NH_3Br]	<7.0	Cation of weak base Anion of strong acid	Cation
Acidic [$Al(NO_3)_3$, $CrCl_3$, $FeBr_3$]	<7.0	Small, highly charged cation Anion of strong acid	Cation
Basic [CH_3COONa, KF, Na_2CO_3]	>7.0	Cation of strong base Anion of weak acid	Anion



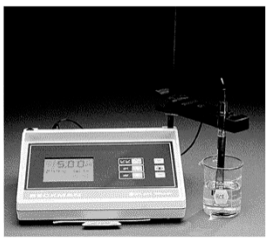
$LiNO_2$ NH_4Cl $Ca(NO_3)_2$

http://chemconnections.org/general/movies/pHofSaltSolutions.swf

$MgSO_4$ $AgClO_3$ $CsCN$

Methods for Measuring the pH of an Aqueous Solution

(a) pH paper



(b) Electrodes of a pH meter

Acid-Base Equilibrium

BUFFERS

Dr. Ron Rusay

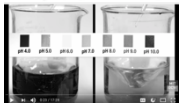
BUFFERS

Weak Acid-Weak Base Systems

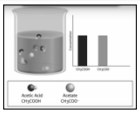
Example:

$H_2CO_3(aq)$ / $HCO_3^{-1}(aq)$ / $CO_3^{-2}(aq)$

$CO_2(g) + H_2O(l) \leftrightarrows HCO_3^{-1}(aq) + H^{+1}(aq) \leftrightarrows CO_3^{-2}(aq) + H^{+1}(aq)$



https://www.youtube.com/watch?v=XR_0k8JIawY



https://www.youtube.com/watch?v=ZLKEjXbCU30

QUESTION

In the following equilibrium:

$HCO_3^-(aq) + H_2O(l) \leftrightarrows H_2CO_3(aq) + OH^-(aq)$

A) HCO_3^- is an acid and H_2CO_3 is its conjugate base.
B) H_2O is an acid and OH^- is its conjugate base.
C) HCO_3^- is an acid and OH^- is its conjugate base.
D) H_2O is an acid and H_2CO_3 is its conjugate base.
E) H_2O is an acid and HCO_3^- is its conjugate base.

Answer

In the following equilibrium:

$HCO_3^-(aq) + H_2O(l) \leftrightarrows H_2CO_3(aq) + OH^-(aq)$

A) HCO_3^- is an acid and H_2CO_3 is its conjugate base.
B) H_2O is an acid and OH^- is its conjugate base.
C) HCO_3^- is an acid and OH^- is its conjugate base.
D) H_2O is an acid and H_2CO_3 is its conjugate base.
E) H_2O is an acid and HCO_3^- is its conjugate base.

$H_2CO_3(aq)$ / $HCO_3^{-1}(aq)$ / $CO_3^{-2}(aq)$

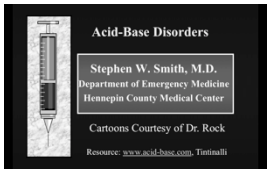
Two VERY IMPORTANT Buffer Systems

"Bicarbonate"

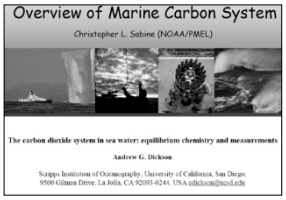
$CO_2(g) + H_2O(l) \leftrightarrows HCO_3^{-1}(aq) + H^{+1}(aq) \leftrightarrows CO_3^{-2}(aq) + H^{+1}(aq)$

1. **Blood:** a human's blood serum volume is relatively small, 4-6 Liters with a narrow pH range, pH = 7.35 – 7.45; pH is maintained through buffering (homeostasis)
   Have you ever had respiratory alkalosis during an exam?
2. **Oceans:** an extraordinarily large volume of a "salt water" solution with a pH ~ 8.1; maintained through buffering

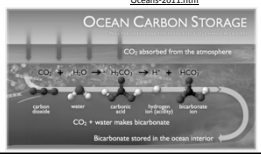
Human & Oceanic Bicarbonate Buffer Systems



http://chemconnections.org/general/chem121/Buffers/Buffers-Med-Pres.htm

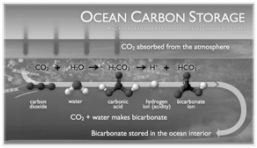


http://chemconnections.org/general/chem121/Buffers/Buffers-CO2-Oceans-2011.htm



EQUILIBRIUM

CO_2 & Oceanic Bicarbonate Buffering



$CO_2(g) + H_2O(l) \leftrightarrows HCO_3^{-1}(aq) + H^{+1}(aq) \leftrightarrows CO_3^{-2}(aq) + H^{+1}(aq)$

Oceans: pH ~ 8.1 and falling
http://www.tos.org/oceanography/issues/issue_archive/22_4.html
Increasing CO_2 is decreasing ocean pH; long term effects?
http://sos.noaa.gov/datasets/Ocean/ocean_acidification.html

Lab: litmus & pH paper; universal Indicator

		Red Litmus	Blue Litmus	Solution pH pH Paper	Solution pH Indicator	Description
A	HCl(aq) stomach acid	red	red	1	2	acid
B	NaOH(aq) drain cleaner	blue	blue	11	10	base
C	$H_2O(l)$ deionized water					
D	$H_2O(l) + CO_2(aq)$ carbonated water (Seltzer)					
E	$Na_2CO_3(aq)$ baking soda					
F	NaOCl(aq) bleach					
G	$CH_3COOH(aq)$ vinegar					
H	NaCl(aq) salt solution					
I	$CH_3COO^-, Na^+(aq)$ salt solution					

J	$NH_4Cl(aq)$ ammonium chloride					
K	$NH_3(aq)$ ammonia (household cleaner)					
L	$Mg(OH)_2$ Milk of Magnesia					
M	Orange juice					
N	Milk					
O	Saliva (spit) and blood	blue	blue	7.4		
P	Vomit	red	red	2.0		
Q	Buffer (pH 7)	red	blue	7.0		Neutral (BOTH acid & base)

Completed Report & Post Lab Questions

Due Today:

Laboratory Manual Seven
Solution Problem Report Form
pp. 76-80; DUE Today

POST LAB Form DUE Today

http://www.chemconnections.org/general/chem108/7-Solutions%20Post%20Lab%20form.pdf

Turn in one completed form with the name of each partner who contributed on the form.

Lab pH: Universal Indicator

		Red Litmus	Blue Litmus	Solution pH	Description
A	$HCl(aq)$ stomach acid	red	red	1.0	acid
B	$NaOH(aq)$ drain cleaner	blue	blue	13.0	base
C	$H_2O(l)$ deionized water			7.0	
D	$H_2O(l) + CO_2(aq)$ carbonated water (Seltzer)			6.4	
E	$Na_2CO_3(aq)$ baking soda			10.1	
F	$NaOCl(aq)$ bleach			8.3	
G	$CH_3COOH(aq)$ vinegar			4.7	
H	$NaCl(aq)$ salt solution			7.0	
I	$CH_3COO^-, Na^+(aq)$ salt solution			9.0	

J	$NH_4Cl(aq)$ ammonium chloride			6.0	
K	$NH_3(aq)$ ammonia (household cleaner)			10.8	
L	$Mg(OH)_2$ Milk of Magnesia			12.0	
M	Orange juice			5.4	
N	Milk			6.4	
O	Saliva (spit) and blood	blue	blue	7.4	
P	Vomit	red	red	2.0	
Q	Buffer (pH 7)			7.0	(*BOTH*: acid & base)