

Updated: 5 February 2020 [Print version](#)

CEE 680: Water Chemistry

Lecture #9
Acids & Bases: Analytical Solutions with
simplifying assumptions III
(Stumm & Morgan, Chapt.3)
(Benjamin, Chapt. 3)

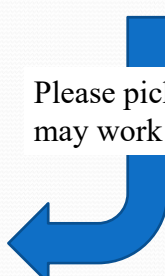
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In-class Practice

- 10^{-4}M Hydrofluoric Acid
 - UMass: JQ & Ian
 - UNISA: Godfrey
- 10^{-2}M Phenol
 - UMass: Cielo, Alvin, Chris
 - UNISA: Hezron & Naledi; Alfred & Ronald; Olayemi
- 10^{-3}M Carbonic Acid
 - UMass: Laura, Isaac, Bridgette
 - UNISA: ???
- 10^{-4}M Sulfuric Acid
 - UNISA: Niall

Other UNISA students:
Nomcebo, Phumlile,
Kelebogile, Ngonidzashe,
Sikelelwa, Umhle, Pfano,
Liberty

Please pick one; you
may work in groups



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NAME	EQUILIBRIA	pK _a
Perchloric acid	$\text{HClO}_4 = \text{H}^+ + \text{ClO}_4^-$	-7 STRONG
Hydrochloric acid	$\text{HCl} = \text{H}^+ + \text{Cl}^-$	-3
Sulfuric acid	$\text{H}_2\text{SO}_4 = \text{H}^+ + \text{HSO}_4^-$	-3 (&2) ACIDS
Nitric acid	$\text{HNO}_3 = \text{H}^+ + \text{NO}_3^-$	-0
Hydronium ion	$\text{H}_3\text{O}^+ = \text{H}^+ + \text{H}_2\text{O}$	0
Trichloroacetic acid	$\text{CCl}_3\text{COOH} = \text{H}^+ + \text{CCl}_3\text{COO}^-$	0.70
Iodic acid	$\text{HIO}_3 = \text{H}^+ + \text{IO}_3^-$	0.8
Dichloroacetic acid	$\text{CHCl}_2\text{COOH} = \text{H}^+ + \text{CHCl}_2\text{COO}^-$	1.48
Bisulfate ion	$\text{HSO}_4^- = \text{H}^+ + \text{SO}_4^{2-}$	2
Phosphoric acid	$\text{H}_3\text{PO}_4 = \text{H}^+ + \text{H}_2\text{PO}_4^-$	2.15 (&7.2,12.3)
Ferric ion	$\text{Fe}(\text{H}_2\text{O})_6^{+3} = \text{H}^+ + \text{Fe}(\text{OH})(\text{H}_2\text{O})_5^{+2}$	2.2 (&4.6)
Chloroacetic acid	$\text{CH}_2\text{ClCOOH} = \text{H}^+ + \text{CH}_2\text{ClCOO}^-$	2.85
o-Phthalic acid	$\text{C}_6\text{H}_4(\text{COOH})_2 = \text{H}^+ + \text{C}_6\text{H}_4(\text{COOH})\text{COO}^-$	2.89 (&5.51)
Citric acid	$\text{C}_3\text{H}_5\text{O}(\text{COOH})_3 = \text{H}^+ + \text{C}_3\text{H}_5\text{O}(\text{COOH})_2\text{COO}^-$	3.14 (&4.77,6.4)
Hydrofluoric acid	$\text{HF} = \text{H}^+ + \text{F}^-$	3.2
Formic Acid	$\text{HCOOH} = \text{H}^+ + \text{HCOO}^-$	3.75
Aspartic acid	$\text{C}_2\text{H}_6\text{N}(\text{COOH})_2 = \text{H}^+ + \text{C}_2\text{H}_6\text{N}(\text{COOH})\text{COO}^-$	3.86 (&9.82)
m-Hydroxybenzoic acid	$\text{C}_6\text{H}_4(\text{OH})\text{COOH} = \text{H}^+ + \text{C}_6\text{H}_4(\text{OH})\text{COO}^-$	4.06 (&9.92)
Succinic acid	$\text{C}_2\text{H}_4(\text{COOH})_2 = \text{H}^+ + \text{C}_2\text{H}_4(\text{COOH})\text{COO}^-$	4.16 (&5.61)
p-Hydroxybenzoic acid	$\text{C}_6\text{H}_4(\text{OH})\text{COOH} = \text{H}^+ + \text{C}_6\text{H}_4(\text{OH})\text{COO}^-$	4.48 (&9.32)
Nitrous acid	$\text{HNO}_2 = \text{H}^+ + \text{NO}_2^-$	4.5
Ferric Monohydroxide	$\text{FeOH}(\text{H}_2\text{O})_5^{+2} + \text{H}^+ + \text{Fe}(\text{OH})_2(\text{H}_2\text{O})_4^+$	4.6
Acetic acid	$\text{CH}_3\text{COOH} = \text{H}^+ + \text{CH}_3\text{COO}^-$	4.75
Aluminum ion	$\text{Al}(\text{H}_2\text{O})_6^{+3} = \text{H}^+ + \text{Al}(\text{OH})(\text{H}_2\text{O})_5^{+2}$	4.8

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NAME	FORMULA	pK _a
Propionic acid	$\text{C}_2\text{H}_5\text{COOH} = \text{H}^+ + \text{C}_2\text{H}_5\text{COO}^-$	4.87
Carbonic acid	$\text{H}_2\text{CO}_3 = \text{H}^+ + \text{HCO}_3^-$	6.35 (&10.33)
Hydrogen sulfide	$\text{H}_2\text{S} = \text{H}^+ + \text{HS}^-$	7.02 (&13.9)
Dihydrogen phosphate	$\text{H}_2\text{PO}_4^- = \text{H}^+ + \text{HPO}_4^{2-}$	7.2
Hypochlorous acid	$\text{HOCl} = \text{H}^+ + \text{OCl}^-$	7.5
Copper ion	$\text{Cu}(\text{H}_2\text{O})_6^{+2} = \text{H}^+ + \text{CuOH}(\text{H}_2\text{O})_5^+$	8.0
Zinc ion	$\text{Zn}(\text{H}_2\text{O})_6^{+2} = \text{H}^+ + \text{ZnOH}(\text{H}_2\text{O})_5^+$	8.96
Boric acid	$\text{B}(\text{OH})_3 + \text{H}_2\text{O} = \text{H}^+ + \text{B}(\text{OH})_4^-$	9.2 (&12.7,13.8)
Ammonium ion	$\text{NH}_4^+ = \text{H}^+ + \text{NH}_3$	9.24
Hydrocyanic acid	$\text{HCN} = \text{H}^+ + \text{CN}^-$	9.3
p-Hydroxybenzoic acid	$\text{C}_6\text{H}_4(\text{OH})\text{COO}^- = \text{H}^+ + \text{C}_6\text{H}_4(\text{O})\text{COO}^{2-}$	9.32
Orthosilicic acid	$\text{H}_4\text{SiO}_4 = \text{H}^+ + \text{H}_3\text{SiO}_4^-$	9.86 (&13.1)
Phenol	$\text{C}_6\text{H}_5\text{OH} = \text{H}^+ + \text{C}_6\text{H}_5\text{O}^-$	9.9
m-Hydroxybenzoic acid	$\text{C}_6\text{H}_4(\text{OH})\text{COO}^- = \text{H}^+ + \text{C}_6\text{H}_4(\text{O})\text{COO}^{2-}$	9.92
Cadmium ion	$\text{Cd}(\text{H}_2\text{O})_6^{+2} = \text{H}^+ + \text{CdOH}(\text{H}_2\text{O})_5^+$	10.2
Bicarbonate ion	$\text{HCO}_3^- = \text{H}^+ + \text{CO}_3^{2-}$	10.33
Magnesium ion	$\text{Mg}(\text{H}_2\text{O})_6^{+2} = \text{H}^+ + \text{MgOH}(\text{H}_2\text{O})_5^+$	11.4
Monohydrogen phosphate	$\text{HPO}_4^{2-} = \text{H}^+ + \text{PO}_4^{3-}$	12.3
Calcium ion	$\text{Ca}(\text{H}_2\text{O})_6^{+2} = \text{H}^+ + \text{CaOH}(\text{H}_2\text{O})_5^+$	12.5
Trihydrogen silicate	$\text{H}_3\text{SiO}_4^- = \text{H}^+ + \text{H}_2\text{SiO}_4^{2-}$	12.6
Bisulfide ion	$\text{HS}^- = \text{H}^+ + \text{S}^{2-}$	13.9
Water	$\text{H}_2\text{O} = \text{H}^+ + \text{OH}^-$	14.00
Ammonia	$\text{NH}_3 = \text{H}^+ + \text{NH}_2^-$	23
Hydroxide	$\text{OH}^- = \text{H}^+ + \text{O}^{2-}$	24
Methane	$\text{CH}_4 = \text{H}^+ + \text{CH}_3^-$	34

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Guide to Simplified Acid/Base Solutions #1

- Neutral
 - if $C < 10^{-8}$
- Acid Addition, $C > 10^{-6.5}$
 - Acidic
 - if $K_a C > 10^{-13}$
 - Strong Acid
 - if $K_a > 10C$
 - Weak Acid
 - if $C > 100K_a$

$$[H^+] \approx \sqrt{K_w}$$

$$[H^+] \approx \frac{-K_a + \sqrt{K_a^2 + 4K_a C}}{2}$$

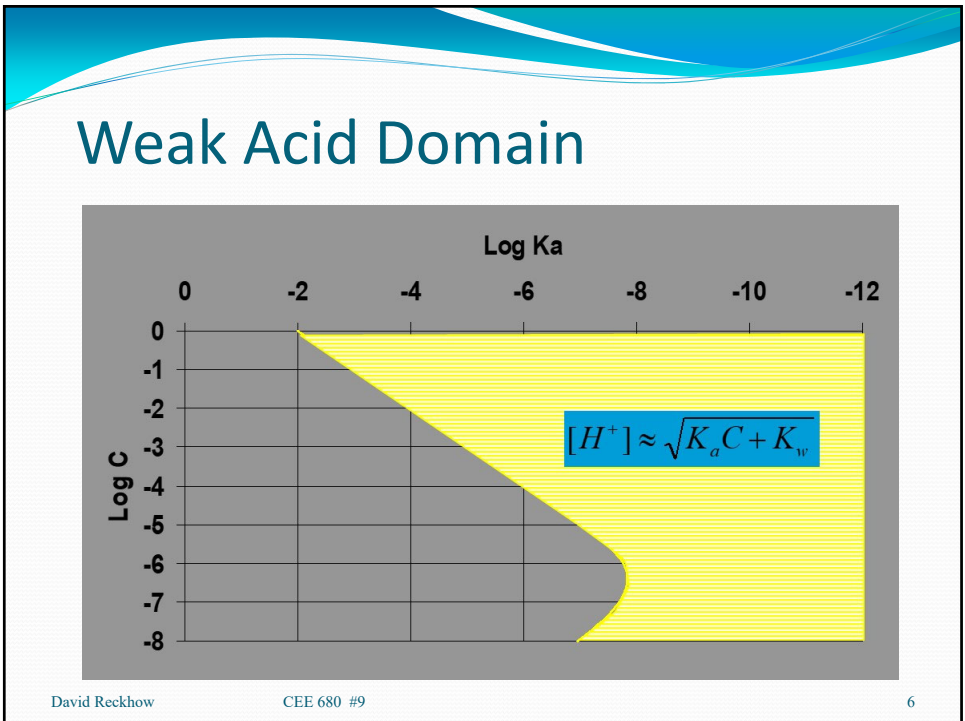
$$[H^+] \approx \frac{C + \sqrt{C^2 + 4K_w}}{2}$$

$$[H^+] \approx \sqrt{K_a C + K_w}$$

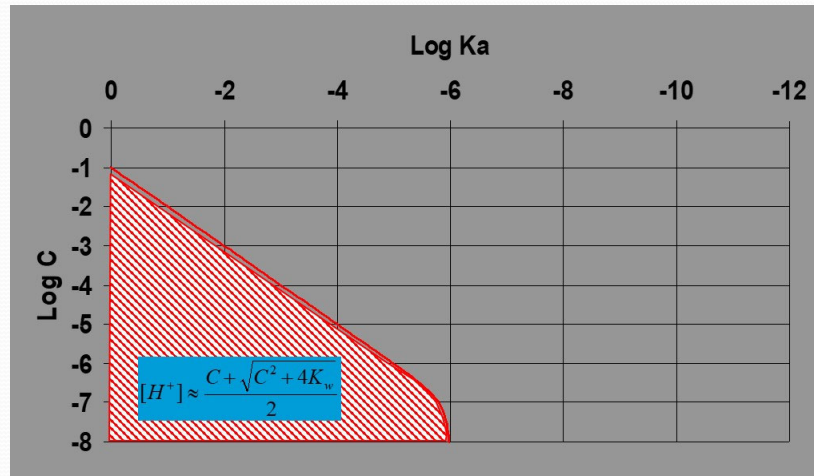
$$[H^+] \approx C$$

$$[H^+] \approx \sqrt{K_a C}$$

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Strong Acid Domain

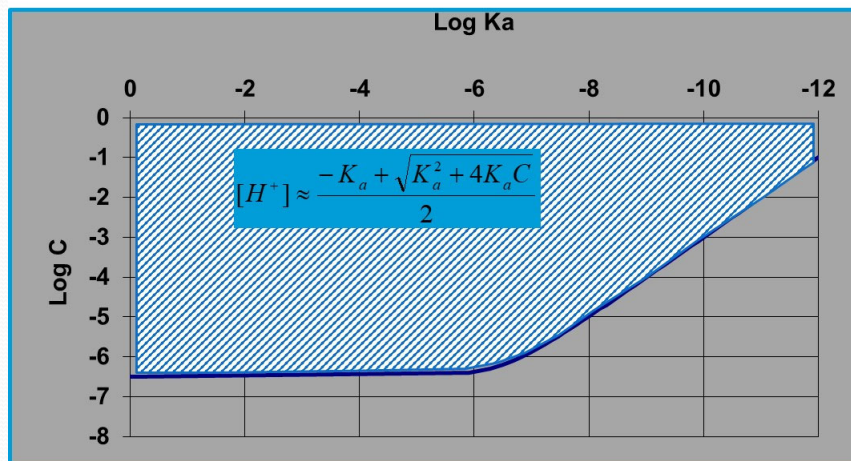


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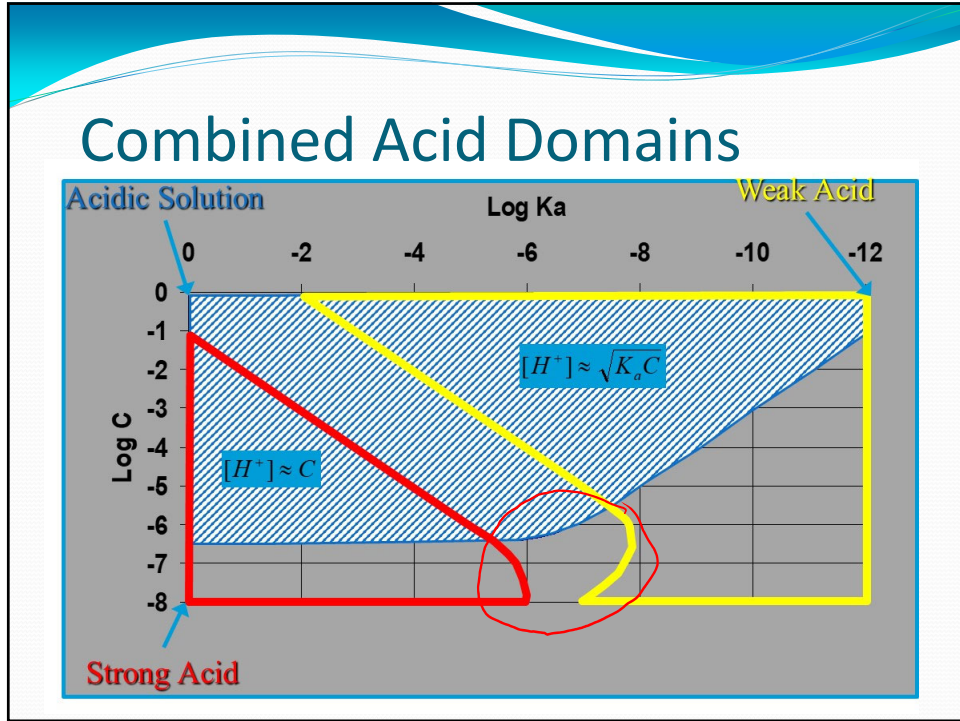
Acidic Solution Domain



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• To next lecture

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