

CEE 680: Water Chemistry

Lecture #9

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

(Benjamin, Chapt. 3)

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



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

NAME	FORMULA	pK _a
Propionic acid	$C_2H_5COOH = H^+ + C_2H_5COO^-$	4.87
Carbonic acid	$H_2CO_3 = H^+ + HCO_3^-$	6.35 (& 10.33)
Hydrogen sulfide	$H_2S = H^+ + HS^-$	7.02 (& 13.9)
Dihydrogen phosphate	$H_2PO_4^- = H^+ + HPO_4^{2-}$	7.2
Hypochlorous acid	$HOCl = H^+ + OCl^-$	7.5
Copper ion	$Cu(H_2O)_6^{+2} = H^+ + CuOH(H_2O)_5^+$	8.0
Zinc ion	$Zn(H_2O)_6^{+2} = H^+ + ZnOH(H_2O)_5^+$	8.96
Boric acid	$B(OH)_3 + H_2O = H^+ + B(OH)_4^-$	9.2 (& 12.7, 13.8)
Ammonium ion	$NH_4^+ = H^+ + NH_3$	9.24
Hydrocyanic acid	$HCN = H^+ + CN^-$	9.3
p-Hydroxybenzoic acid	$C_6H_4(OH)COO^- = H^+ + C_6H_4(O)COO^{2-}$	9.32
Orthosilicic acid	$H_4SiO_4 = H^+ + H_3SiO_4^-$	9.86 (& 13.1)
Phenol	$C_6H_5OH = H^+ + C_6H_5O^-$	9.9
m-Hydroxybenzoic acid	$C_6H_4(OH)COO^- = H^+ + C_6H_4(O)COO^{2-}$	9.92
Cadmium ion	$Cd(H_2O)_6^{+2} = H^+ + CdOH(H_2O)_5^+$	10.2
Bicarbonate ion	$HCO_3^- = H^+ + CO_3^{2-}$	10.33
Magnesium ion	$Mg(H_2O)_6^{+2} = H^+ + MgOH(H_2O)_5^+$	11.4
Monohydrogen phosphate	$HPO_4^{2-} = H^+ + PO_4^{3-}$	12.3
Calcium ion	$Ca(H_2O)_6^{+2} = H^+ + CaOH(H_2O)_5^+$	12.5
Trihydrogen silicate	$H_3SiO_4^- = H^+ + H_2SiO_4^{2-}$	12.6
Bisulfide ion	$HS^- = H^+ + S^{2-}$	13.9
Water	$H_2O = H^+ + OH^-$	14.00
Ammonia	$NH_3 = H^+ + NH_2^-$	23
Hydroxide	$OH^- = H^+ + O^{2-}$	24
Methane	$CH_4 = H^+ + CH_3^-$	34

Guide to Simplified Acid/Base Solutions #1

- Neutral

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

- if $C < 10^{-8}$

- Acid Addition, $C > 10^{-6.5}$

- Acidic

- if $K_a C > 10^{-13}$

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

- Strong Acid

- if $K_a > 10C$

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

- Weak Acid

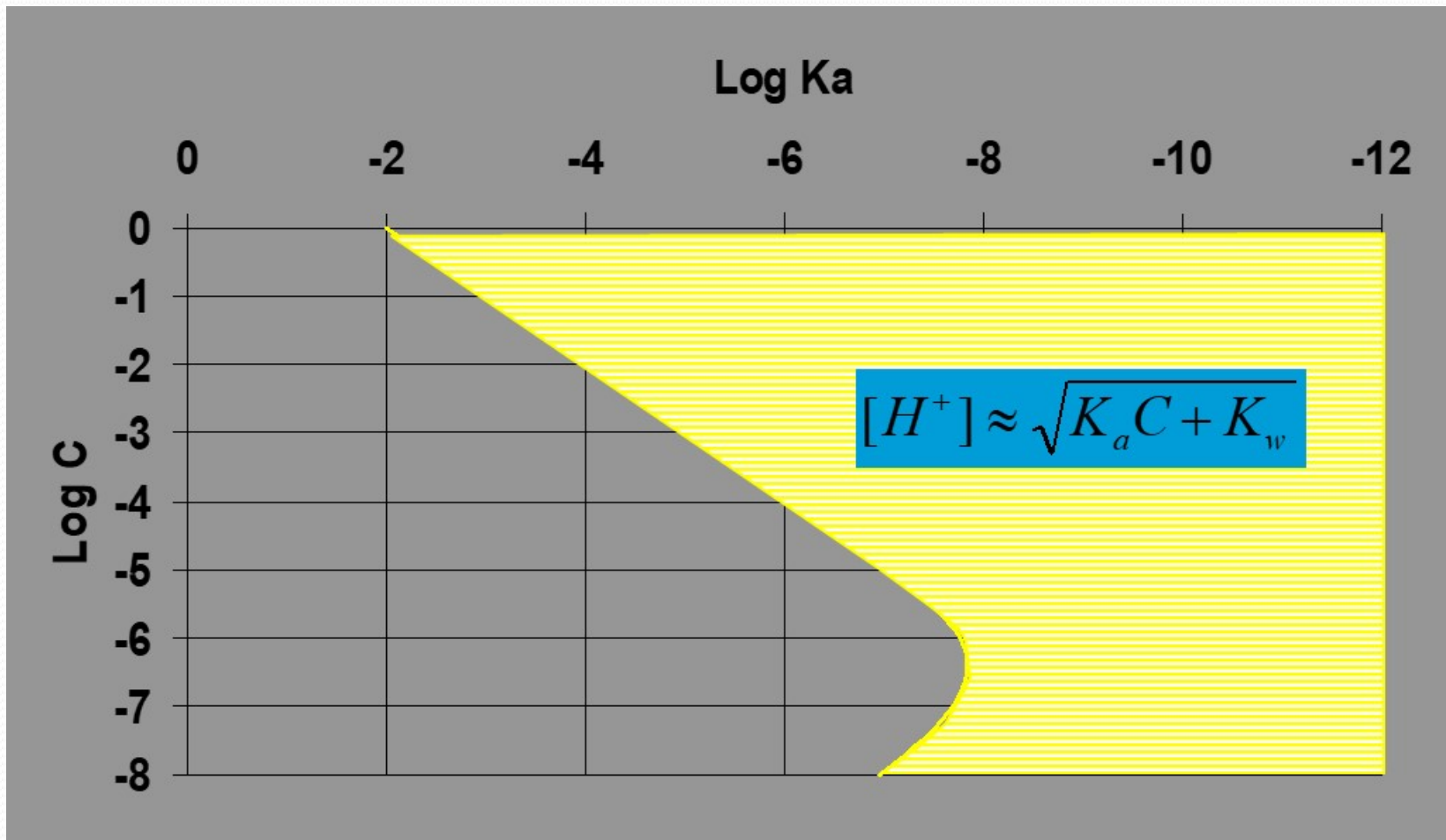
- if $C > 100K_a$

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

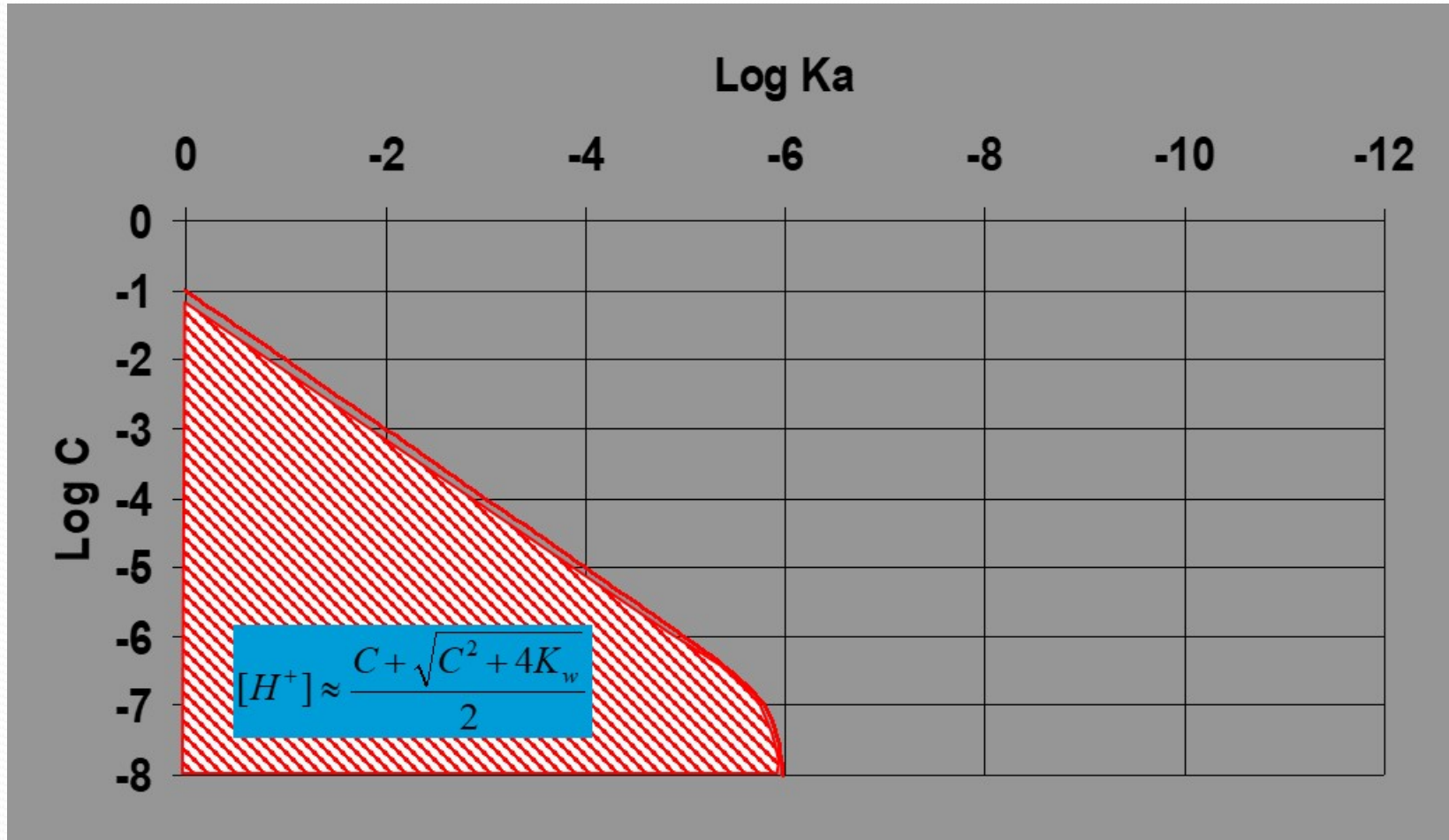
$$[H^+] \approx C$$

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

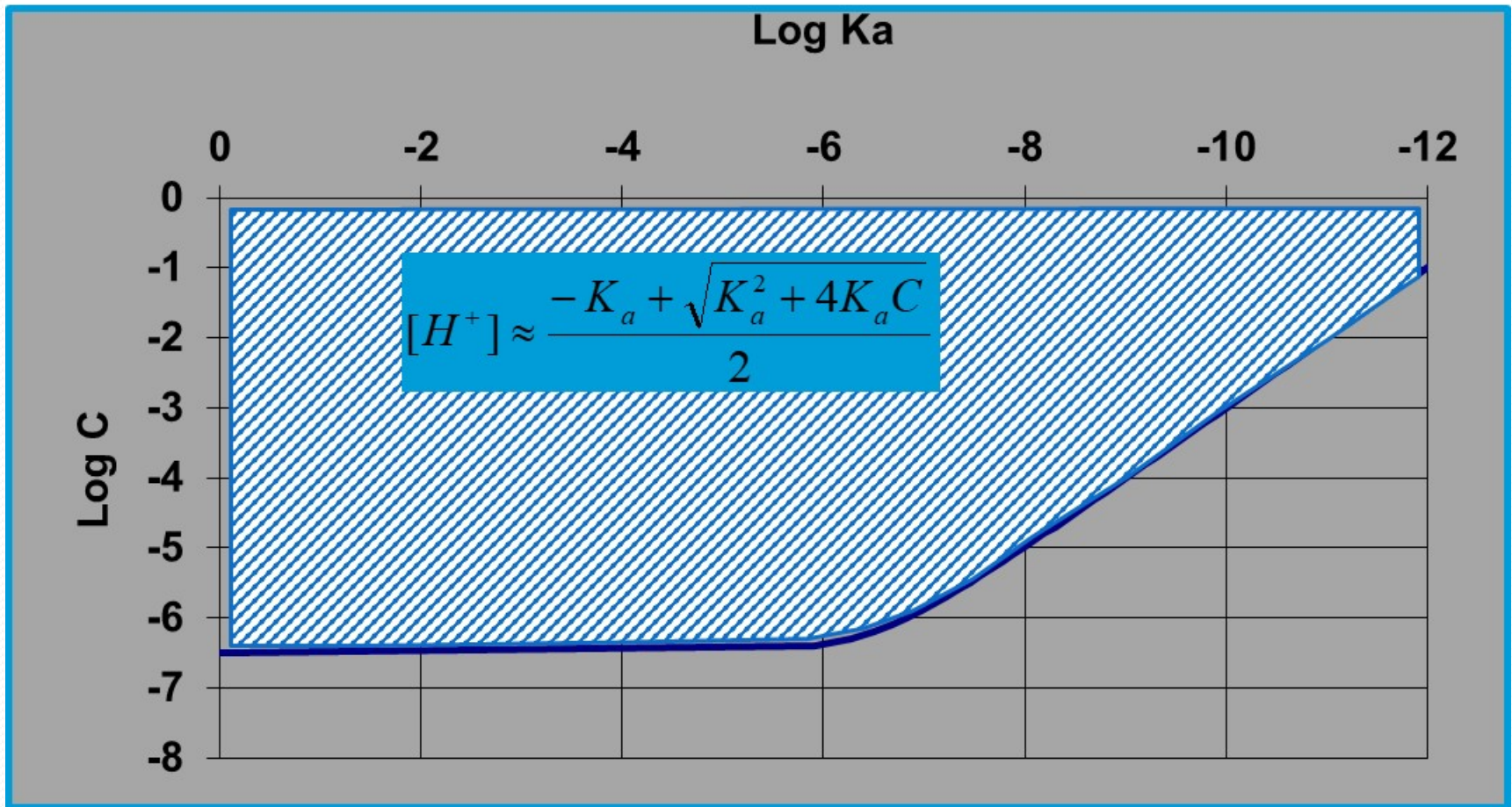
Weak Acid Domain



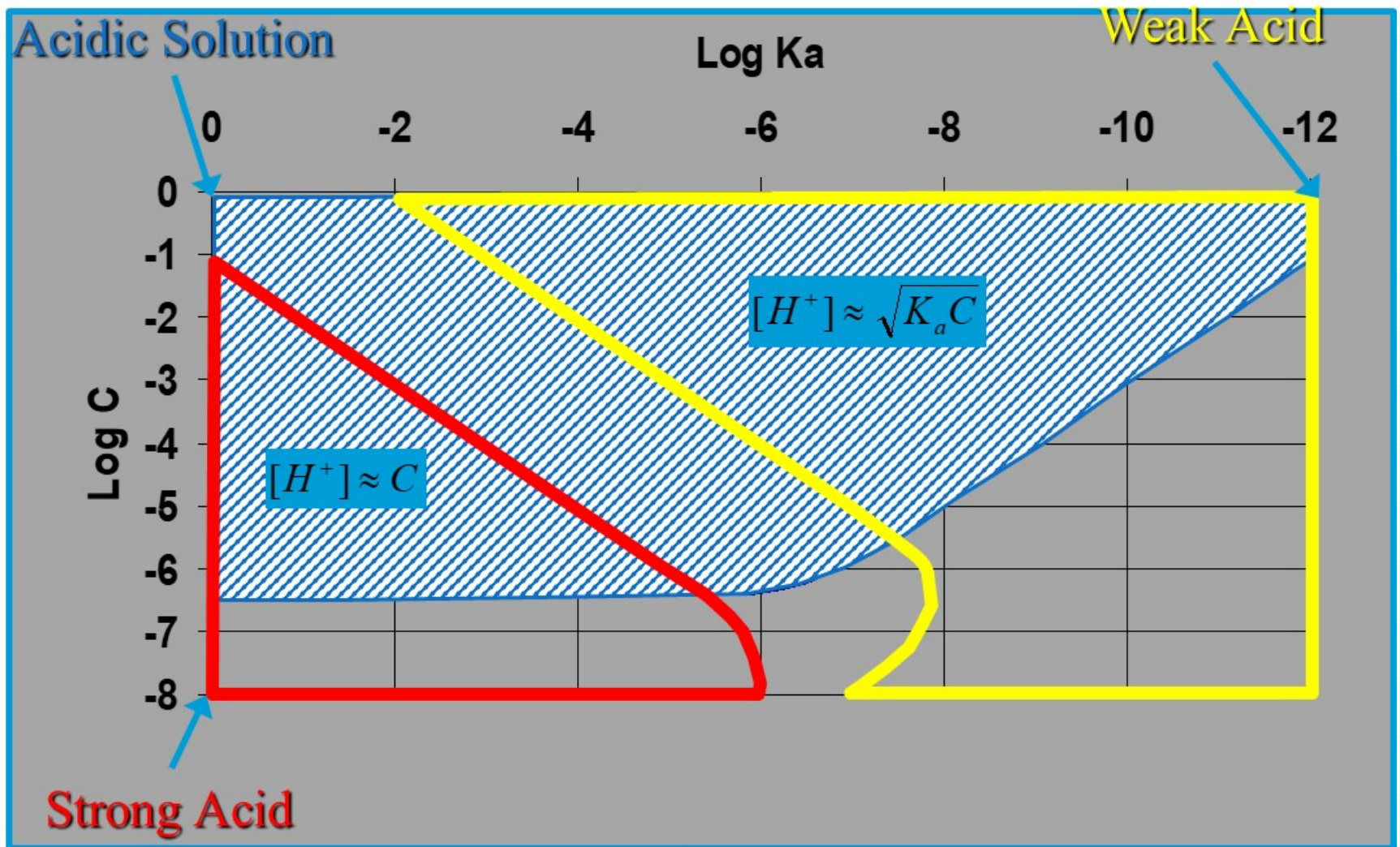
Strong Acid Domain



Acidic Solution Domain



Combined Acid Domains



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