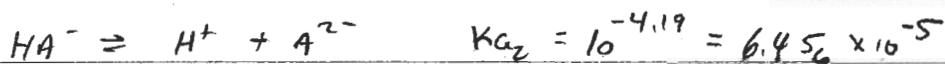
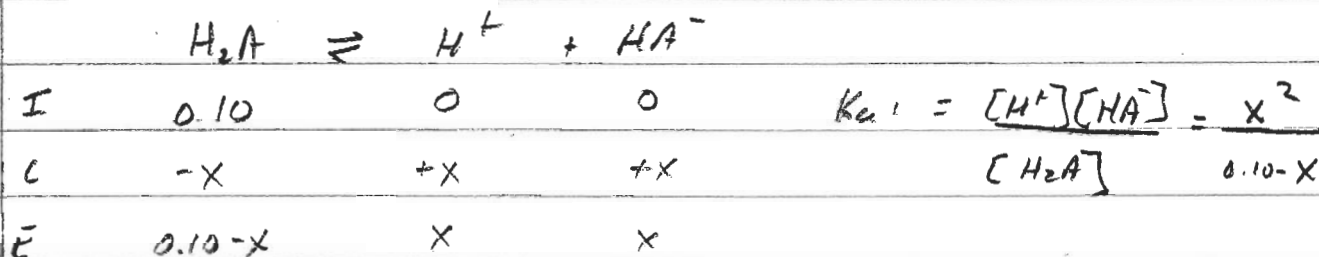


Oxalic Acid Bonus

Oxalic acid (H_2A) $pK_{a1} = 1.23$, $pK_{a2} = 4.19$



Since $K_{a2} \ll K_{a1}$, assume only K_{a1} contributes significantly to pH



$$\therefore x^2 + K_{a1}x - 0.10K_{a1} = 0$$

$$x = 0.05275, -0.116$$

$$\therefore x = [H^+] = 0.05275 \text{ M}, \quad \underline{\underline{pH = 1.278}}$$

Systematic Approach (including autoprotolysis of water)

mass balance:

$$0.10 \text{ M} = [H_2A] + [HA^-] + [A^{2-}]$$

Charge Balance:

$$[H^+] = [HA^-] + 2[A^{2-}] + [OH^-]$$

Equilibrium Constants

$$K_{a1} = \frac{[H^+][HA^-]}{[H_2A]}$$

$$K_{a2} = \frac{[H^+][A^{2-}]}{[HA^-]}$$

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

Goal: get everything in terms of $[H^+]$

$$[H_2A] = \frac{[H^+][HA^-]}{K_{a1}} \quad [A^{2-}] = \frac{K_{a2}[HA^-]}{[H^+]}$$

mass balance

$$0.10 \text{ M} = \frac{[H^+][HA^-]}{K_{a1}} + [HA^-] + \frac{K_{a2}[HA^-]}{[H^+]}$$

$$\therefore [HA^-] = \frac{0.10 \text{ M}}{\frac{[H^+]}{K_{a1}} + 1 + \frac{K_{a2}}{[H^+]}}$$

Charge Balance

$$[H^+] = [HA^-] + 2\left(\frac{K_{a2}[HA^-]}{[H^+]}\right) + \frac{K_w}{[H^+]}$$

\therefore "guess" $[H^+]$, calculate $[HA^-]$ + new $[H^+]$
 - repeat until $[H^+]$ does not change

After executing the calculation, we get to convergence and a $[H^+] = 0.0528_{13} \text{ M}$ or $\text{pH} = \underline{\underline{1.279}}$

	A	B	C	D	E	F	G	H	I
1		K _{a1}	0.058884366		Final [H ⁺]	=	0.052813		
2		K _{a2}	6.45654E-05		pH =		1.277		
3		K _w	1E-14						
4									
5									
6	Iteration	[H ⁺]	[HA ⁻]						
7	1	0.1000000	0.0370523						
8	2	0.0371001	0.0612824						
9	3	0.0614957	0.0488903						
10	4	0.0489929	0.0545453						
11	5	0.0546891	0.0518152						
12	6	0.0519376	0.0530991						
13	7	0.0532312	0.0524877						
14	8	0.0526150	0.0527772						
15	9	0.0529067	0.0526398						
16	10	0.0527682	0.0527049						
17	11	0.0528339	0.0526740						
18	12	0.0528027	0.0526887						
19	13	0.0528175	0.0526817						
20	14	0.0528105	0.0526850						
21	15	0.0528138	0.0526834						
22	16	0.0528122	0.0526842						
23	17	0.0528130	0.0526838						
24	18	0.0528126	0.0526840						
25	19	0.0528128	0.0526839						
26	20	0.0528127	0.0526839						
27	21	0.0528128	0.0526839						
28	22	0.0528127	0.0526839						
29	23	0.0528128	0.0526839						
30	24	0.0528128	0.0526839						
31	25	0.0528128	0.0526839						
32	26	0.0528128	0.0526839						
33	27	0.0528128	0.0526839						
34	28	0.0528128	0.0526839						
35	29	0.0528128	0.0526839						
36	30	0.0528128	0.0526839						
37	31	0.0528128	0.0526839						
38	32	0.0528128	0.0526839						
39	33	0.0528128	0.0526839						
40	34	0.0528128	0.0526839						
41	35	0.0528128	0.0526839						
42	36	0.0528128	0.0526839						
43	37	0.0528128	0.0526839						
44	38	0.0528128	0.0526839						
45	39	0.0528128	0.0526839						
46	40	0.0528128	0.0526839						
47	41	0.0528128	0.0526839						

$$[HA^-] = \frac{0.10}{\frac{[H^+]}{K_{a1}} + 1 + \frac{K_{a2}}{[H^+]}}$$

$$[H^+] = [HA^-] + 2 \left(\frac{K_{a2}[HA^-]}{[H^+]} \right) + \frac{K_w}{[H^+]}$$

B8 = +C7+(\$C\$2*C7/B7)+(\$C\$3/B7)
 C8 = =0.1/((B7/\$C\$1)+1+(\$C\$2/B7))

