Pauling's Electronegativity Scale

Table 2.3 Electronegativities of Atoms According to the Scale Devised by Pauling (1960)

Charge of Kernel:	+1	+4	+5	+6	+7	
	H 2.2					Increasing Size of Kernel ↓
		C 2.5	N 3.0	O 3.5	F 4.0	
			P 2.2	S 2.5	Cl 3.0	
					Br 2.8	
					I 2.5	

Source: Environmental Organic Chemistry, Schwarzenbach et al., 2003

Acidity Constants of Some Important Acids

Table 3.2 Chemical formulas and acidity constants of some important acids[3]

Name	Formula	pK_{a1}	pK_{a2}	pK_{a3}	pK_{a4}
Nitric acid	HNO_3	−1.30			
Trichloroacetic acid	CCl_3COOH	−0.5			
Hydrochloric acid	HCl	<0			
Sulfuric acid	H_2SO_4	<0	1.99		
Hydronium ion	H_3O^+	0.00	14.00		
Chromic acid	H_2CrO_4	0.86	6.51		
Oxalic acid	$(COOH)_2$	0.90	4.20		
Dichloroacetic acid	$CHCl_2COOH$	1.1			
Sulfurous acid	H_2SO_3	1.86	7.30		
Phosphoric acid	H_3PO_4	2.16	7.20	12.35	
Arsenic acid	H_3AsO_4	2.24	6.76		
Monochloroacetic acid	$CH_2ClCOOH$	2.86			
Salicylic acid	$C_6H_4OHCOOH$	2.97	13.70		
Citric acid	$C_3H_4OH(COOH)_3$	3.13	4.72	6.33	
Hydrofluoric acid	HF	3.17			
Benzoic acid	C_6H_5COOH	4.20			
Pentachlorophenol	C_6Cl_5OH	4.7			
Acetic acid	CH_3COOH	4.76			
Carbonic acid	H_2CO_3	6.35	10.33		
Hydrogen sulfide	H_2S	6.99	12.92		
Hypochlorous acid	$HOCl$	7.60			
Cupric ion	Cu^{2+}	8.00	5.68		
2-Chloro-phenol	C_6H_4ClOH	8.53			
Hypobromous acid	$HOBr$	8.63			
Zinc ion	Zn^{2+}	8.96	8.94		
Arsenous acid	H_3AsO_3	9.23	12.10		
Hydrocyanic acid	HCN	9.24			
Boric acid	H_4BO_4	9.24			
Ammonium ion	NH_4^+	9.25			
2,4-Dichloro-phenol	$C_6H_3Cl_2OH$	9.43			
Silicic acid	H_4SiO_4	9.84	13.20		
Phenol	C_6H_5OH	9.98			
Cadmium ion	Cd^{2+}	10.08	10.27	12.95	14.05
Calcium ion	Ca^{2+}	12.60			

Source: Water Chemistry, Benjamin, 2010

Weak Mono-Protic Acid Solution

Weak Acid: A weak acid, when added to water is incompletely dissociated.

CH_3COOH is a weak **mono-protic** acid. When added to water, it partially dissociates, such that both the CH_3COO^- and CH_3COOH exist simultaneously in water. The degree of dissociation depends on the dissociation constant.

$$CH_3COOH \rightleftarrows CH_3COO^- + H^+ \qquad K_a = 10^{-4.8}$$

$pK_a = 4.8$ (actually 4.76 as per Table 3.2)

Example Problem:

What is the pH of 10^{-3} M HAc solution ?

$[Ac^-] + [HAc] = C_A = 10^{-3}$ M

$[H^+].[OH^-] = K_w = 10^{-14}$

$$K_a = \frac{[H^+].[Ac^-]}{[HAc]} = 10^{-4.8}$$

Charge Balance: $[H^+] = [OH^-] + [Ac^-]$

$$K.[HAc] = [H^+].C_A - [H^+].[HAc]$$

$$[HAc] = \frac{[H^+]}{K + [H^+]}.C_A = \alpha_o.C_A$$

Similarly,

$$[Ac^-] = \frac{K}{K + [H^+]}.C_A = \alpha_1.C_A$$

$$[H^+] = \frac{K_W}{[H^+]} + \alpha_1.C_A$$

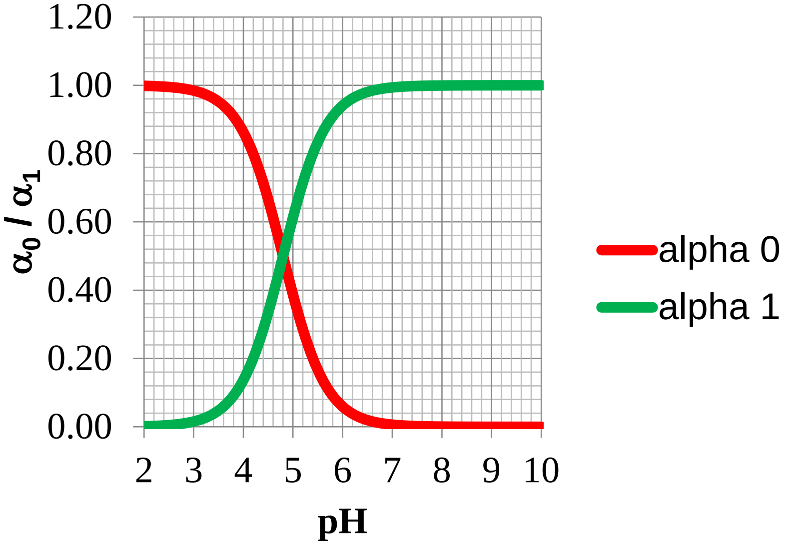
Solving Eq. (A) we can find $[H^+]$

Ans: pH = 3.92; $[HAc] = 8.82 \times 10^{-4}$ M
$[Ac^-] = 1.18 \times 10^{-4}$ M

But How?? **Using Excel Worksheet**

Speciation of a Weak Mono-Protic Acid Solution as a Function of pH

Variation of α_0 / α_1 of HAc with pH



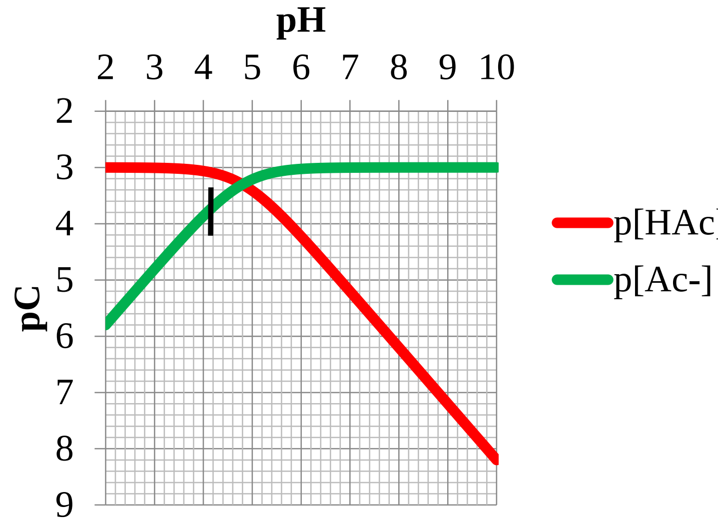
At a given pH the concentration of,
[HAc] = α_0. $C_{A;}$ [Ac^-] = α_1. C_A

C_A = [HAc] +[Ac^-];   pK = 4.8

Note that [HAc] = [Ac^-] when pH = pK
At pH > pK, [Ac^-] predominates
At pH < pK, [HAc] predominates

All these results are true, irrespective of whatever else is present in solution.

pC-pH Diagram of HAc
$C_A = 10^{-3}$ M



pH of 10^{-3} M HAc solution is 3.92

Corresponding,
p[HAc] = 3.05   p[Ac^-] = 3.93

If the pH of this solution is increased or decreased by addition of other base/acids, the [HAc] and [Ac^-] concentrations will be as shown in the pC-pH diagram, provided C_A remains the same.