CH1202: Lab Report III

Determination of the pK_{In} value of an acid-base indicator by spectrophotometric method

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§1 Brief Theory and Equation

Most of the acid-base indicator are technically weak acid (represented as HIn). In some solutions, it dissociates:

$$\text{HIn} \rightleftharpoons \text{H}^+ + \text{In}^-$$

which yields the Henderson-Hasselbalch equation:

$$pH = pK_{\text{In}} + \log \frac{[\text{In}^-]}{[\text{HIn}]}$$

Now to determine the ratio of $\frac{[\text{In}^-]}{[\text{HIn}]}$, we use spectrophotometry. We are acquainted with Beer's law:

$$A = \epsilon c l$$

where A is the absorbance of the solution, ϵ being one of the intrisic property of the solution called the molar attenuation coefficient. We will find A at different pH, which we lead to pK_{In} through Henderson-Hasselbalch equation. This requires a trick of using conservation of mass (since, $m_{\text{H}^+} \ll m_{\text{HIn}}$, we have $m_{\text{HIn}} \simeq m_{\text{In}^-}$), as stated through the following equation (details were avoided):

$$[\text{HIn}] = \frac{A' - A}{\epsilon l}$$

and

$$[\mathrm{In}^-] = \frac{A}{\epsilon l}$$

plugging these back into the Henderson-Hasselbalch equation yields:

$$pH = pK_{\mathrm{In}} + \log \frac{A}{A' - A} \qquad (\star)$$

where A' is the absorbance of solution when HIn and In^- both are present in the solution and in equilibrium, while A denotes the absorbance of solution only In^- is present in the solution. The equation $(\star)$ is the working formula for this experiment.

§2 Dataset

Sl. No.	Vol. of Oxalic acid (mL)	Burette reading (mL)			Avg. Vol. (mL)	Strength of NaOH (N)
		Initial	Final	Difference		
1	10	0	10	10	10.1	0.5
2	10	0	10.2	10.2		
3	10	0	10.1	10.2		

Table 1: Standardization of NaOH solution with Oxalic acid

Sl. No.	Vol. of Acetic acid (mL)	Burette reading (mL)			Avg. Vol. (mL)	Strength of Acetic acid (N)
		Initial	Final	Difference		
1	10	0	10	10	9.9	0.5
2	10	11	20.9	9.9		
3	10	0	9.9	9.9		

Table 2: Standardization of Acetic acid solution using standardized NaOH

Test tube	Vol. of 0.4 N Acetic acid (mL)	Vol. of 0.4 N NaOH (mL)	Vol. of water (mL)	pH (expt.)	A	$\lambda = \frac{A}{A'-A}$	$\log(\lambda)$
1	5	0.5	4.5	3.72	0.0783	0.1218	-0.9144
2	5	1.5	3.5	4.27	0.2469	0.5221	-0.2835
3	5	2.5	2.5	4.63	0.3934	1.2001	0.0792
4	5	3.5	1.5	4.99	0.5168	2.5284	0.4028
5	5	4.5	0.5	5.57	0.7144	105.0588	2.0214
6	0	2.5	7.5	$A' = 0.7212$			

Table 3: Spectrophotometric data

§3 Plots

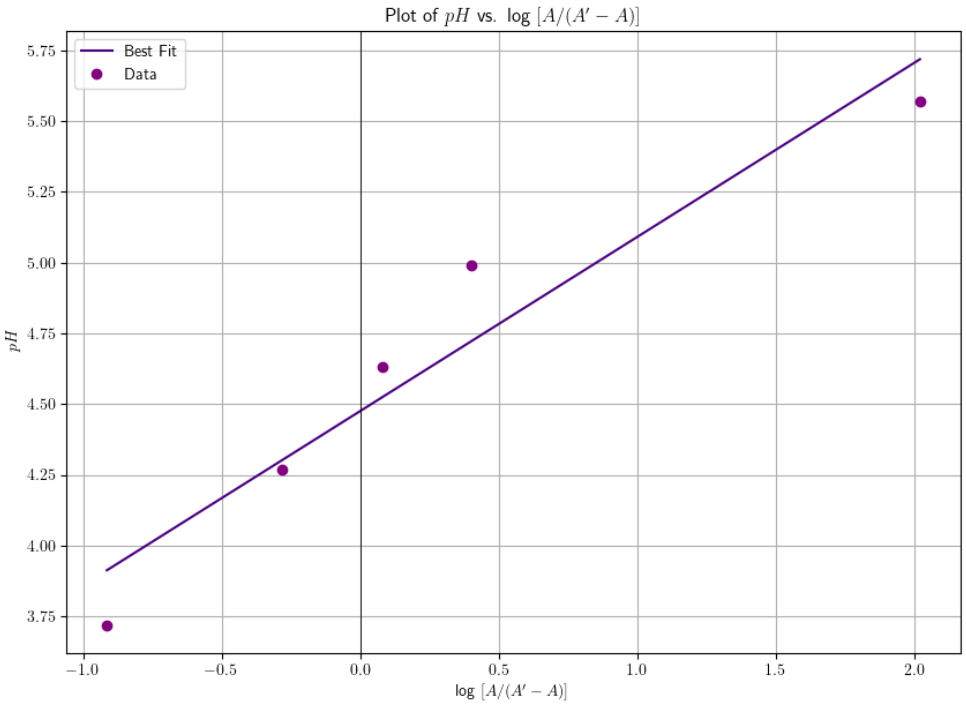

Figure 1: Fitting the experimented data

§4 Results

From the above graph, by finding the y-intercept of the line we got by fitting (linear-regression) is $pK_{\text{In}} = 4.48$, with a fitting error in intercept $= 2.26\%$.