PH Meter

A. Theory

1) The pH of an aq. solution can be measured using glass calomel electrode system in which the following electrochemical cell is formed.

Ag/AgCl(S)/0.1(M)HCl/Glass/solution of unknown pH /saturated calomel electrode.

2) The glass electrode is the most widely used hydrogen ion responsive electrode and its use depends on the fact that when a glass membrane is immersed in a solution a potential is developed which is a linear function of the hydrogen ion concentration of the solution.
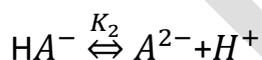
The potential of the glass electrode at 25°C may be expressed as-

$E_g = E_g° + 0.059 \log a_{H^+}$

$E_g = E_g° - 0.059$ pH, $[as\ pH = -log\ H^+]$

For actual pH measurement the glass electrode is standardised in buffer solution of known pH value.

3) For dibasic acids like oxalic acid or succinct acid (H_2 A) the ionization equilibrium may be represented as,

$H_2 A \overset{K_1}{\Longleftrightarrow} HA^- + H^+$

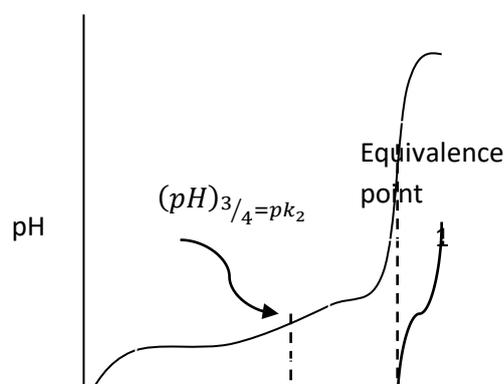$HA^- \overset{K_2}{\Longleftrightarrow} A^{2-} + H^+$

Where K_1 and K_2 are the dissociation constants for the first and second step of dissociation respectively.

For oxalic acid a succinic acid beyond the half-equivalence point the system is a buffer consisting of HA^-, and A^{2-}.

The pH of this buffer solution given by-

$$pH = pk_2 + \log\left\{[A^{2-}]\Big/[HA^-]\right\}$$

pH

$(pH)_{3/4 = pk_2}$

Equivalence point

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At $3/4^{th}$ the equivalence point $[A^{2-}] = [HA^-]$

Hence, $[pH]\,3/4 = pk_2$

Hence by plotting the pH values vs no. of drops of NaOH added, we can calculate the equivalence point from the graph and also $3/4^{th}$ the equivalence point correspond to which we will get $[pH]\,3/4$ which is actually our pk_2.

Equation used: $(pH)_1 = \frac{1}{2}(pk_1 + pk_2)$ $(pH)_{1/2} = pk_1$ $(pH)_2 = \frac{1}{2}(pk_2 + pk_3)$

Experimental results:-

table 1:-

Recording of room temperature

Before experiment	After experiment	Mean temperature
28°C	28°C	28°C

Table 2:-

Preparation of 100ml $(N/10)$ oxalic acid solution in a volumetric flask by accurate weighing .

Mol. wt. of oxalic acid = 63g Oxalic acid required

To prepare 1000 ml 1(N) Oxalic acid = 63g

$\therefore$ To prepare 100ml of standard $(N/10)$ solution, oxalic acid required= $\left(\frac{63}{1000} \times 100 \times \frac{N}{10}\right) gm$ =0.63g

Initial weight(g)	Final weight (g)	Weight taken(g)	Weight to be taken (g)	Strength of oxalic acid
21.012	20.363	0.649	0.63	0.103016(N)

Strength of oxalic acid $=\dfrac{weight\ taken}{weight\ to\ be\ taken} \times (N/10)$

$$=\frac{0.649}{0.63} \times \frac{N}{10}$$

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$$=1.03016(N/10)$$

$$=0.103016(N)$$

Table-3:-

Preparation of 100 ml $\left(\sim\frac{N}{2}\right)$ NaOH by dilution of supplied $(\sim N)$ NaOH solution.

We know,

$$V_1 S_1 = V_2 S_2 \quad \text{Or,} \quad 100 \times \frac{N}{2} = x \times N$$

$$\therefore x = 50\text{ml}$$

$\therefore$ Volume of water required = (100 – 50) ml

$$= 50 \text{ ml}$$

Volume of NaOH required to prepare 100ml $\left(\sim\frac{N}{2}\right)$ NaOH	Volume of distilled water required to prepare 100ml $\left(\sim\frac{N}{2}\right)$ NaOH
50ml	50ml

Table -4 :- drop calibration of prepared $\left(\sim\frac{N}{2}\right)$ NaOH solution – calculating the volume of 1 drop of $\left(\sim\frac{N}{2}\right)$ NaOH by recording the volume of 50 drops from burette .

NO of observations	No. Of drops of $\left(\sim\frac{N}{2}\right)$ NaOH from burette.	Burette reading of $\left(\sim\frac{N}{2}\right)$ NaOH(ml)		Difference (ml)	Mean volume
		initial	final		
1.	50	0	2.2	2.2	2.2
2.	50	0	2.2		

$\therefore$ volume of 1 drop of $\left(\sim\frac{N}{2}\right)$ NaOH $= \frac{2.2}{50}$

$$=0.044 \text{ ml}$$

Table – 5 standardization of $\left(\frac{N}{2}\right)$ NaOH solution by the prepared 100ml $\left(\frac{N}{2}\right)$ oxalic acid solution.

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No of observation.	Volume of oxalic acid(ml)	No of drops of NaOH.	Mean no of drops .	Total no of drops	pH
1		0	1	0	2.03
2		2	3	2	2.06
3		2	5	4	2.10
4		2	7	6	2.05
5		2	9	8	2.20
6		2	11	10	2.26
7	10	2	13.5	12	2.32
8		3	16.16	15	2.44
9		2	18	17	2.54
10		2	20	19	2.67
11		2	22	21	2.83
12		2	24	23	3.03
13		2	26	25	3.32
14		2	28	27	3.51
15		2	28	29	3.67
16		2	30	31	3.83
17		2	32	33	3.96
18		2	34	35	4.11
19		2	36	37	4.26
20		2	38	39	4.44
21		1	39.5	40	4.53
22		1	40.5	41	4.66
23		1	41.5	42	4..80
24		1	42.5	43	5.00
25		1	43.5	44	5.31
26		1	44.5	45	6.19
27		2	46	47	10.5

Table -6 :- pH metric titration with the supplied pH solution (Ph -041)

No of observation.	Vol. o f supplied Ph solution .	No. Of drops of NaOH .	Total no. Of drops of NaOH	PH
1		0	0	2.00
2		2	2	2.02
3		2	4	2.04
4		2	6	2.08
5		2	8	2.11

6		2	10	2.16
7		2	12	2.20
8	10ml	2	14	2.26
9		2	16	2.32
10		2	18	2.39
11		2	20	2.48
12		2	22	2.59
13		2	24	2.72
14		2	26	2.88
15		2	28	3.07
16		2	30	3.26
17		2	32	3.43
18		2	34	3.58
19		2	36	3.71
20		2	38	3.83
21		2	40	3.95
22		2	42	4.08
23		2	44	4.20
24		2	46	4.34
25		2	48	4.50
26		2	49	4.7
27		1	50	4.8
28		1	51	5.0
29		1	52	5.2
30		1	53	5.8
31		1	54	9.60
32		1	55	10.4
33		1	56	10.4

Table -7 :- $\Delta pH / \Delta n$ vs mean no of drops of alkali added for the Ph metric titration of known oxalic acid solution.

pH	ΔpH	Δn	$\Delta pH / \Delta n$	Mean no of drops of NaOH (n)
2.03	0.03	0	0.015	1
2.06	0.04	2	0.02	1
2.10	0.05	2	0.025	3
2.15	0.05	2	0.025	5
2.20	0.06	2	0.03	7

2.26	0.06	2	0.03	9
2.32	0.12	3	0.06	11
2.44	0.10	2	0.05	13.5
2.54	0.13	2	0.065	16
2.67	0.16	2	0.08	18
2.83	0.20	2	0.10	20
3.03	0.29	2	0.145	22
3.32	0.19	2	0.095	24
3.51	0.16	2	0.08	26
3.67	0.16	2	0.08	28
3.83	0.13	2	0.065	30
3.96	0.15	2	0.075	32
4.11	0.15	2	0.075	34
4.26	0.18	2	0.09	36
4.44	0.09	2	0.045	38
4.53	0.09	1	0.09	39.5
4.66	0.13	1	0.13	40.5
4.80	0.14	1	0.14	41.5
5.00	0.20	1	0.20	42.5
5.31	0.31	1	0.31	43.5
6.19	0.88	1	0.88	44.5
10.5	4.31	2	2.155	46

Table 8:- calculation of the concentration of NaOH solution from the plot of $\frac{\Delta pH}{\Delta n}$ vs mean no. of drops of alkali the pH – metric titration of prepared oxalic acid solution.

Vol. Of oxalic acid (ml)	Strength of oxalic acid	Vol . of NaOH added (ml)	Strength NaOH
10	0.103016(N)	46×0.044=2.024	0.51(N)

Vol. Of NaOH = 46×0.044=2.024ml

Vol. Of oxalic acid = 10 ml

Strength of oxalic acid = 0.103016(N)

Strength of NaOH $=\dfrac{Volume\ of\ oxalic\ acid\ \times strength}{vol.of\ NaOH}$

$=\dfrac{10ml\times0.103016(N)}{2.024}$

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Table -9:-

Calculation for the concentration of supplied 'pH' solution (Say, pH-04)

Vol. Of supplied ph solution (ml)	Vol. Of NaOH solution (ml)	Strength of NaOH solution.	Strength of supplied ph solution
10	54.4× 0.044=2.3936	0.51(N)	0.122074(N)

Vol. Of NaOH =54.4× 0.044=2.3936ml

Vol. Of supplied solution taken = 10 ml

Strength of NaOH = 0.51(N)

$\therefore$ Strength of supplied ph solution $=\dfrac{0.51(N)\times2.3936(N)}{10ml}$

=0.122074(N)   (here range was 0.110-0.134)

Calculation for pk_2 of supplied pH solution

No. Of drops of NaOH corresponding to neutralization point = 54.4

No. Of drops corresponding to $3/4^{th}$ neutralization point = 40.8

$\therefore$ (pH)$3/4$ = 4.0

$\therefore pk_2$= pH)$3/4$ =4   (here range for this data is 3.9 -4.2)