pH-metric titration of acidic water by standard base

Introduction

- The pH meter was invented in 1934 by the American chemist Arnold O. Beckman (1900-2004) to measure the sourness of lemons.

- A simple and speedy device to measure the acidity and alkalinity of a fluid.

- pH: the logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per litre; provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral and greater than 7 is more basic and less than 7 is more acidic)

The formal definition of pH is the negative logarithm of the hydrogen ion activity.

$$pH = -\log[H^+]$$

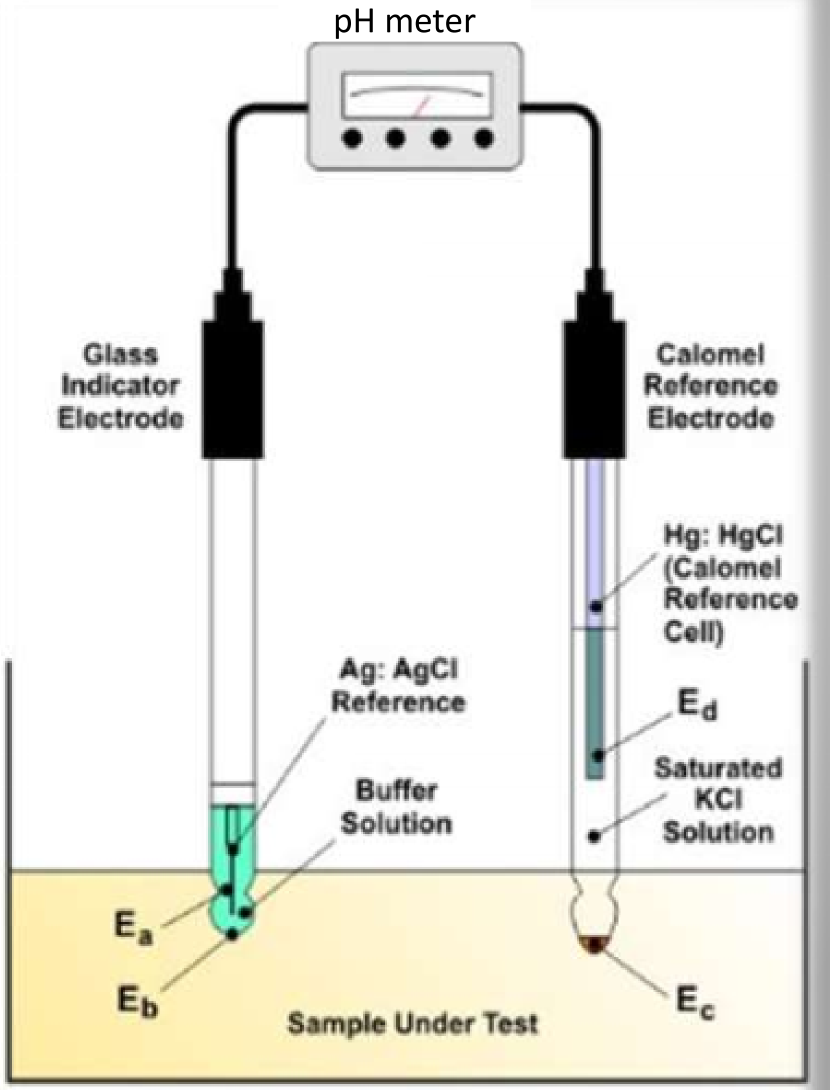
Working Principle

When a pair of electrodes or a combined electrode(glass &calomel electrode) is dipped in an aqueous solution, a potential is developed across the thin glass of the bulb. The e.m.f of complete cell(E) formed by linking of this two electrodes at a given solution temperature is therefore,

$$E = E_{ref} - E_{glass}$$

E_{ref} = The potential of stable calomel electrode which at normal room temp is + 0.242 V.

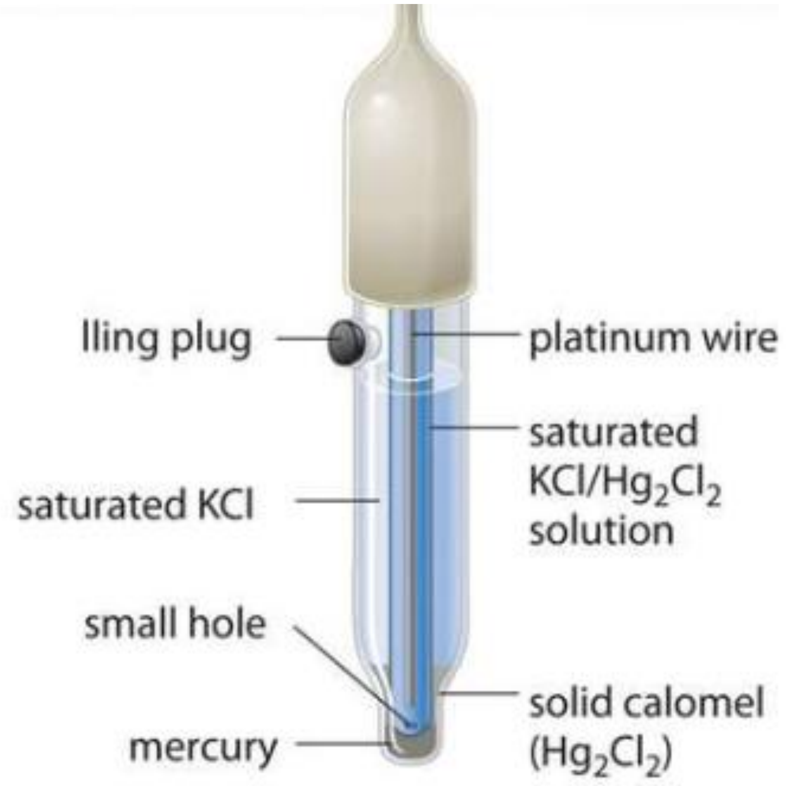
E_{glass} = The potential of glass electrode which depends on the pH of the solution under test.



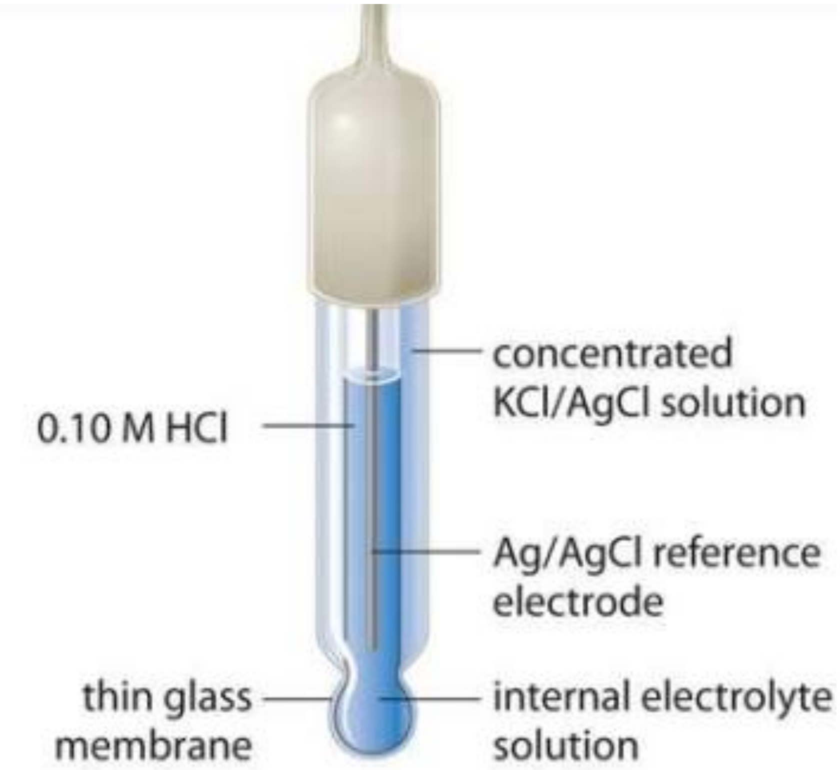
A pH meter acts as a volt meter that measures the electrical potential difference between a pH electrode and a reference electrode and displays the result in terms of the pH value of the solution in which they are immersed.

An electrical potential develops when one liquid is brought into contact with another one ,but a membrane is needed to keep such liquid apart.

Saturated calomel electrode (SCE)

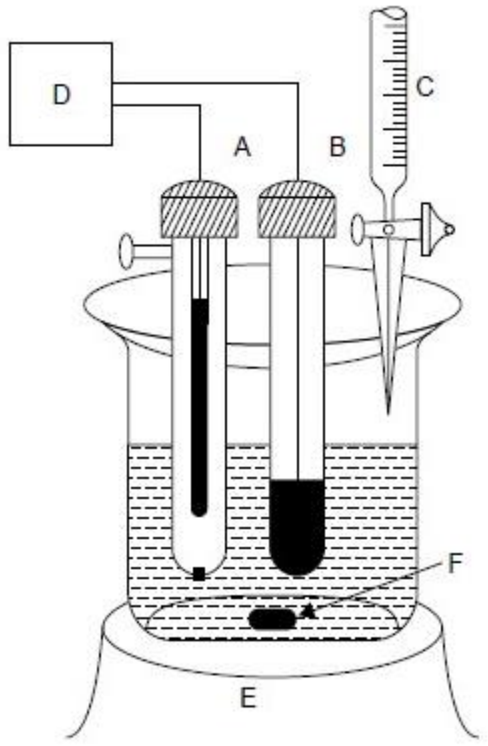


Glass electrode



Aim: To determine the amount of HCl in the given solution, using standard NaOH pH metrically

Requirements: Standard NaOH solution, standard buffer solution, glass electrode, saturated calomel electrode (SCE), HCl solution (of unknown conc.- analyte), pH meter



A = SCE
B = Glass electrode
C = Burette
D = pH Meter
E = Magnetic stirrer
F = Magnetic bead

PROCESS :

(1) Switch on the pH - meter & allow 10 minutes warming up time. Keep theinstrument in 'stand by' mode.

(2) Set the temperature knob to room temperature.

(3) Connect the two electrodes in their proper places to form a complete cell. Wash the glass & calomel electrodes with distilled water & blot dry with paper. Immerse them in a beaker containing distilled water.

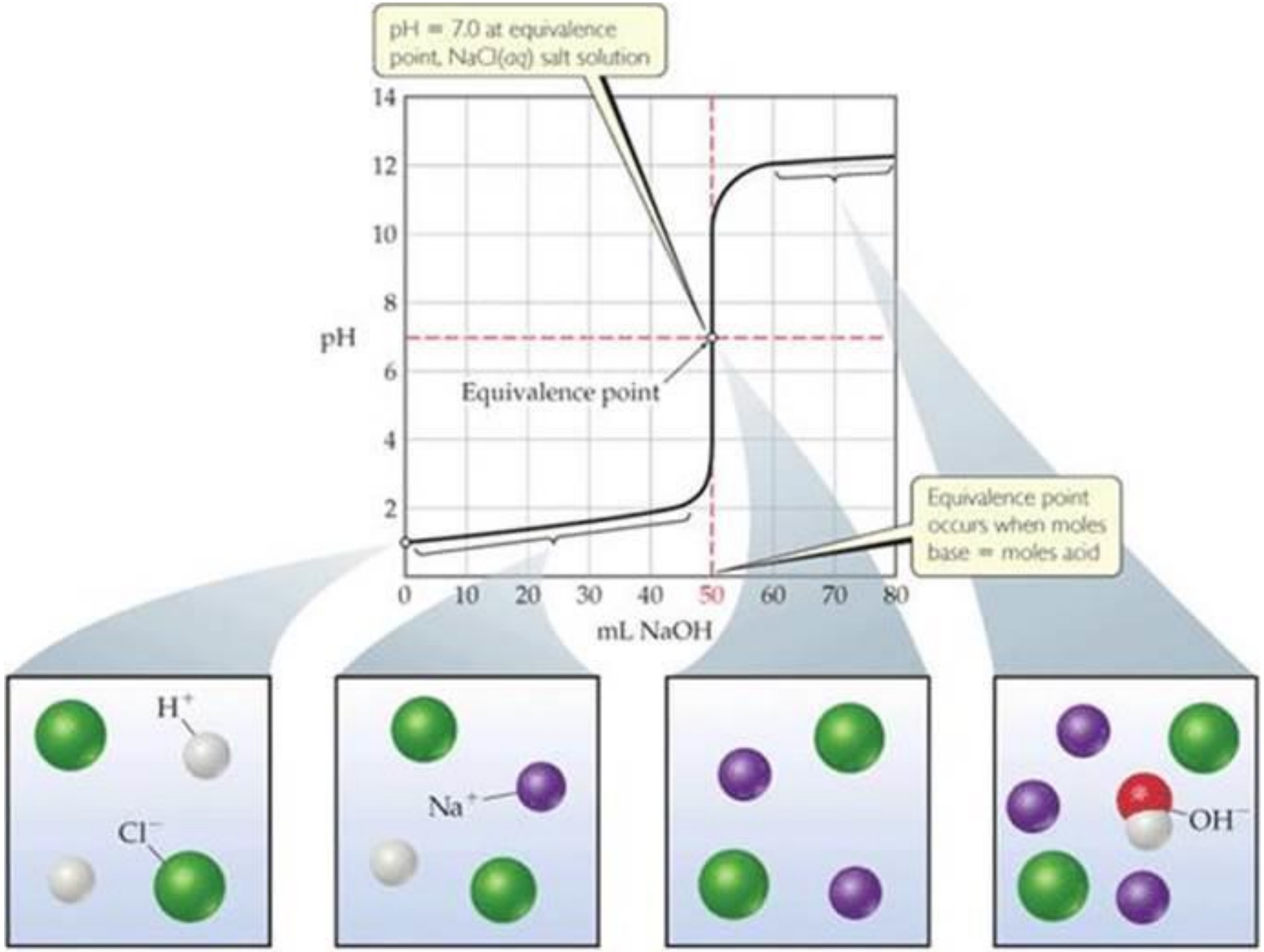
(4) With the help of the knot named ' power on off brings the needle to pH scale 7.0.

(5) Remove the electrodes from distilled water, dry them & immerse them in a buffer solution of known pH. Change the instrument from 'stand by' mode 'Read'. The needle will deflect to show some pH. With the help of calibrating knob during the needle to the correct pH of buffer solution. The instrument is thus calibrated

(6) Take 25 ml of the acid solution in a 50 ml beaker.

(7) Remove the electrodes from the buffer solution, wash them with distilled water, blot dry using paper.

(8) Immerse the electrodes in a beaker containing 25 ml of HCl solution. Turn the knob from 'stand by' to 'read' mode & observe the pH. This is the Zero reading. Add 0.5 ml of NaOH the solution from the burette & stir well. Note the pH. Kip on adding NaOH & observe pH after each successive addition of 0.5 ml of NaOH. Take four or above readings after the end point is reached.



Only HCl(aq) present before titration

H^+ consumed as OH^- added, forming H_2O (pH < 7.0)

H^+ completely neutralized by OH^- (pH = 7.0)

No H^+ left to react with excess OH^- (pH > 7.0)

OBSERVATIONS :

BURETTE : 0.25N NaOH Solution

BEAKER : 25 mL diluted HCl Solution

OBSERVATION TABLE

Pilot Reading :-

No.	Volume of 0.25N NaOH 'V' (mL)	pH	ΔpH	Δ V	ΔpH/ΔV
1	0	0.68	—	—	—
2	1	0.76	0.08	1	0.08
3	2	0.89	0.013	1	0.13
4	3	1.08	0.19	1	0.19
5	4	1.05	0.42	1	0.42
6	5	11.78	10.28	1	10.28
7	6	12.48	0.70	1	0.70
8	7	12.67	0.19	1	0.19
9	8	12.82	0.15	1	0.15
10	9	12.91	0.09	1	0.09

Actual Reading:-

No.	Volume of 0.25N NaOH 'V' (mL)	pH	ΔpH	Δ V	ΔpH/ΔV
1	0	0.69	–	–	–
2	1	0.76	0.07	1	0.07
3	2	0.89	0.13	1	0.013
4	3	1.14	0.15	1	0.25
5	4	1.80	0.66	1	0.66
6	4.1	1.82	0.02	0.1	0.20
7	4.2	1.88	0.06	0.1	0.6
8	4.3	2.14	0.26	0.1	2.6
9	4.4	2.40	0.34	0.1	2.6
10	4.5	2.70	0.56	0.1	3.40
11	4.6	9.30	1.03	0.1	65.6
12	4.7	10.33	0.90	0.1	10.3
13	4.8	11.23	0.43	0.1	9.0
14	4.9	11.66	0.13	0.1	4.3
15	5.0	11.79	0.69	0.1	1.3
16	6	12.48	0.22	1	0.69
17	7	12.70	0.22	1	0.22
18	8	12.82	0.12	1	0.12
19	9	12.92	0.10	1	0.10
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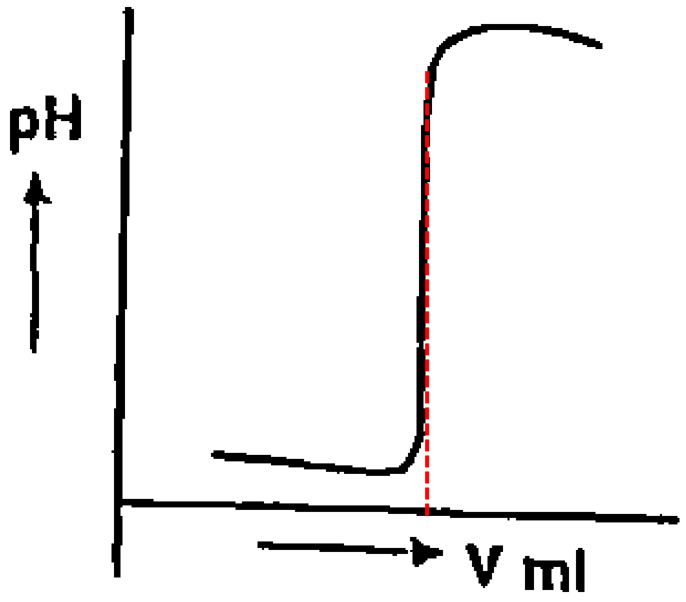
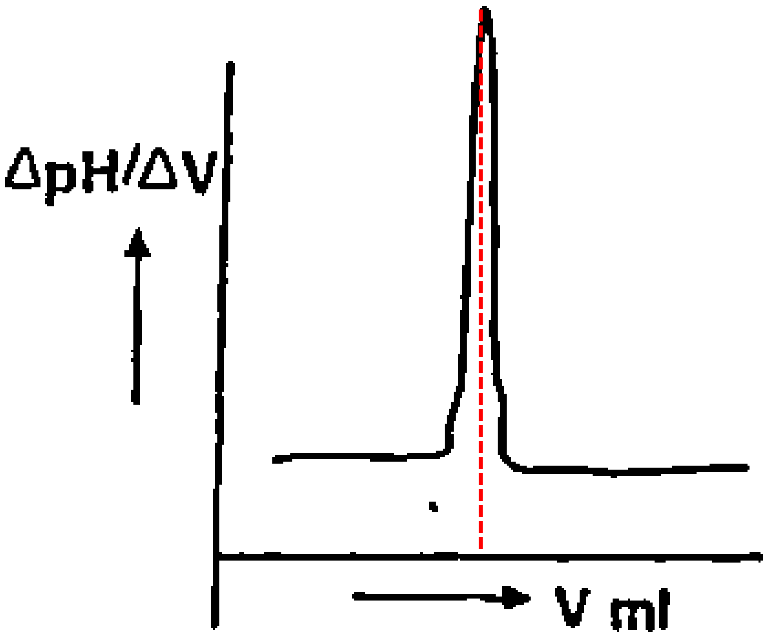

pH
V ml


ΔpH/ΔV
V ml

CALCULATIONS :

(1) Normality of diluted HCl $= \dfrac{\text{Normality of NaOH} \times \text{Vol. NaOH}}{\text{Vol. HCl}}$

$= \dfrac{0.25 \times Vo}{25} = \dfrac{0.25 \times 4.5}{25}$

$=$ 'A' = 0.046 N

(2) Amount of HCl in

25 ml diluted Soln. $=$ Normality of dil. HCl x Equivalent wt. HCl

$=$ 'A' x 36.5 g.

$=$ 'B' $= \dfrac{1.68 \times 25}{100}$ g.

$= 0.042$ g.

RESULT :

(1) Normality of diluted HCl Soln. = 'A' N = 0.046 N

(2) Amount of HCl in given Soln. = 'B' gm = 0.042 g.