Date 24/11/20

Expt. No. 8

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EXPERIMENT: To determine pKa value of acetic acid by pH metric titration.

THEORY: A pH meter will be used to follow the titration of an unknown weak acid, HA(aq.) with sodium hydroxide, NaOH (aq.). The weak acid has a concentration around 0.1M. The result of the pH versus volume of NaOH plot is 'S' shaped curve which is not as steep as the one arising from the titration of a strong acid. The equivalence point (titr. time) will be at alkaline pH (not 7 as in strong acid vs strong base). From the equivalence point, the concentration of an unknown acid HA is found. In addition, the acid constant $K_a$ can be determined.

PROCEDURE:

Titration of unknown HA with standard NaOH

1. Calibrate the pH meter with the standard buffer solution of pH = 4 or 9, then rinse the glass electrode and immerse it in the beaker. Position the burette so that the titrant can be easily added.
2. Pipette out 50mL of acetic acid into a clean beaker, dip the glass electrode. Record the pH.
3. Initially, add 0.5 mL of 0.1 NaOH solution at a time, record the pH (after each addition), until the pH change is more than 0.2 - 0.3 units, then start adding 0.2 mL of NaOH each time (i.e., near to the equivalence point, decrease the volume of NaOH added) so that the change in pH is small enough

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EXPERIMENT: To determine pKa value of acetic acid by pH metric titration.

APPARATUS: Pipette, burette, beakers, funnel, burette stand, clamp, pH meter and glass electrode.

CHEMICALS: Sodium Hydroxide (NaOH) and acetic acid ($CH_3COOH$).

CHEMICAL REACTIONS:

$$HA(aq) + NaOH(aq) \longrightarrow NaA(aq) + H_2O$$

$$HA + H_2O \longrightarrow H_3O^+ + A^-$$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

$$pH = pK_a + \log \frac{[\text{salt form}]}{[\text{acid form}]}$$

Henderson-Hasselbalch Equation

DIAGRAM:

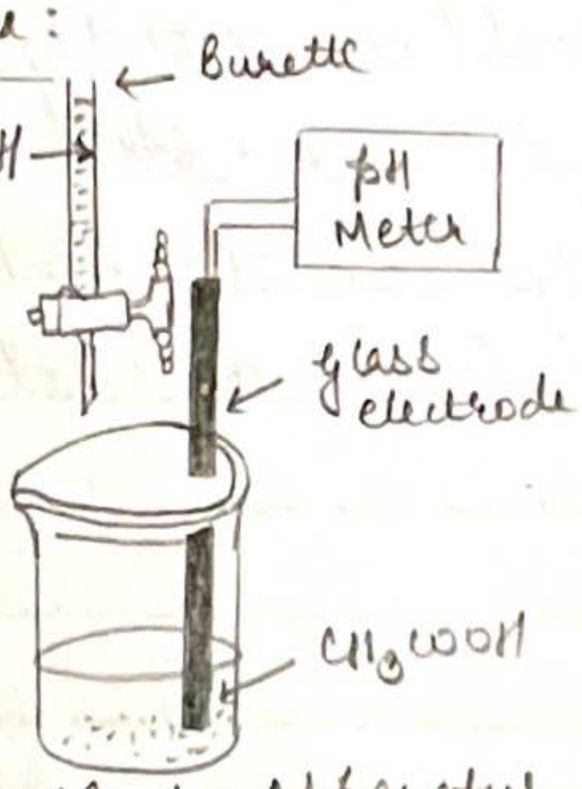


Fig. 1: Apparatus

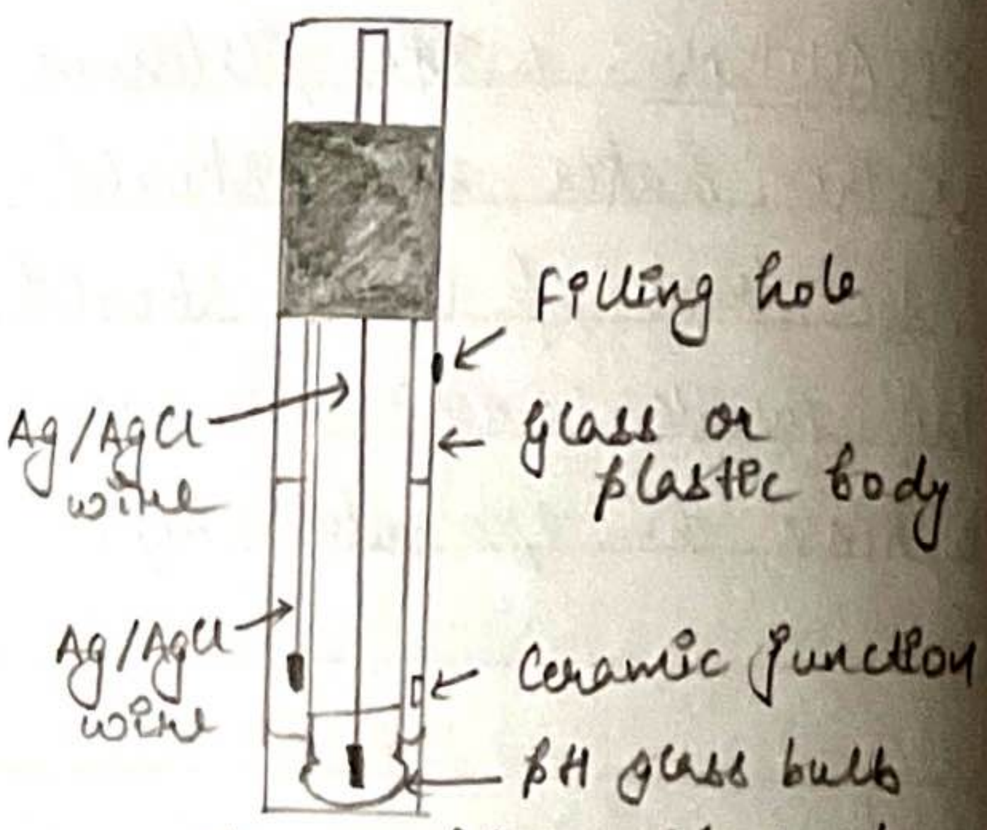


Fig. 2: Glass Electrode

to yield a good shape of plot.

4. After the rapid change in pH (after the equivalence point), the volume of NaOH may again be increased to 0.5 ml per addition. Make at least 10 more additions after the equivalence point so that the region with the plateau can be plotted.

5. pKa is determined by explaining the titration curve. The negative log of Ka is pKa and is same as the pH at half the volume of equivalence point.
(pH = pKa when logarithmic term is zero which in turn is zero once [salt] = [acid]. This is true at half equivalence point)

RESULT: The pKa of acetic acid is 4.65.

PRECAUTIONS : 1. Rinse the apparatus before experimenting
2. The drops of NaOH should directly fall into the beaker from the burette and not on the wall of beaker or electrode.
3. The glass electrode should be correctly placed in the beaker and should not be used as a stirrer.

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OBSERVATIONS:

Normality of standard NaOH = 0.1N

| S. No. | Volume of NaOH added from the burette (mL) | pH | S. No. | Volume of NaOH added from the burette (mL) | pH |
|---|---|---|---|---|---|
| 1. | 0.5 | 2.84 | 16. | 8.0 | 5.45 |
| 2. | 1.0 | 3.76 | 17. | 8.5 | 5.61 |
| 3. | 1.5 | 3.95 | 18. | 9.0 | 5.96 |
| 4. | 2.0 | 4.09 | 19. | 9.5 | 9.35 |
| 5. | 2.5 | 4.23 | 20. | 10.0 | 12.00 |
| 6. | 3.0 | 4.35 | 21. | 10.5 | 12.35 |
| 7. | 3.5 | 4.43 | 22. | 11.0 | 12.51 |
| 8. | 4.0 | 4.55 | 23. | 11.5 | 12.63 |
| 9. | 4.5 | 4.64 | 24. | 12.0 | 12.69 |
| 10. | 5.0 | 4.74 | 26. | 12.5 | 12.75 |
| 11. | 5.5 | 4.84 | 26. | 13.0 | 12.81 |
| 12. | 6.0 | 4.91 | 27. | 13.5 | 12.86 |
| 13. | 6.5 | 5.04 | 28. | 14.0 | 12.89 |
| 14. | 7.0 | 5.17 | 29. | 14.5 | 12.93 |
| 16. | 7.5 | 5.30 | 30. | 15.0 | 12.94 |

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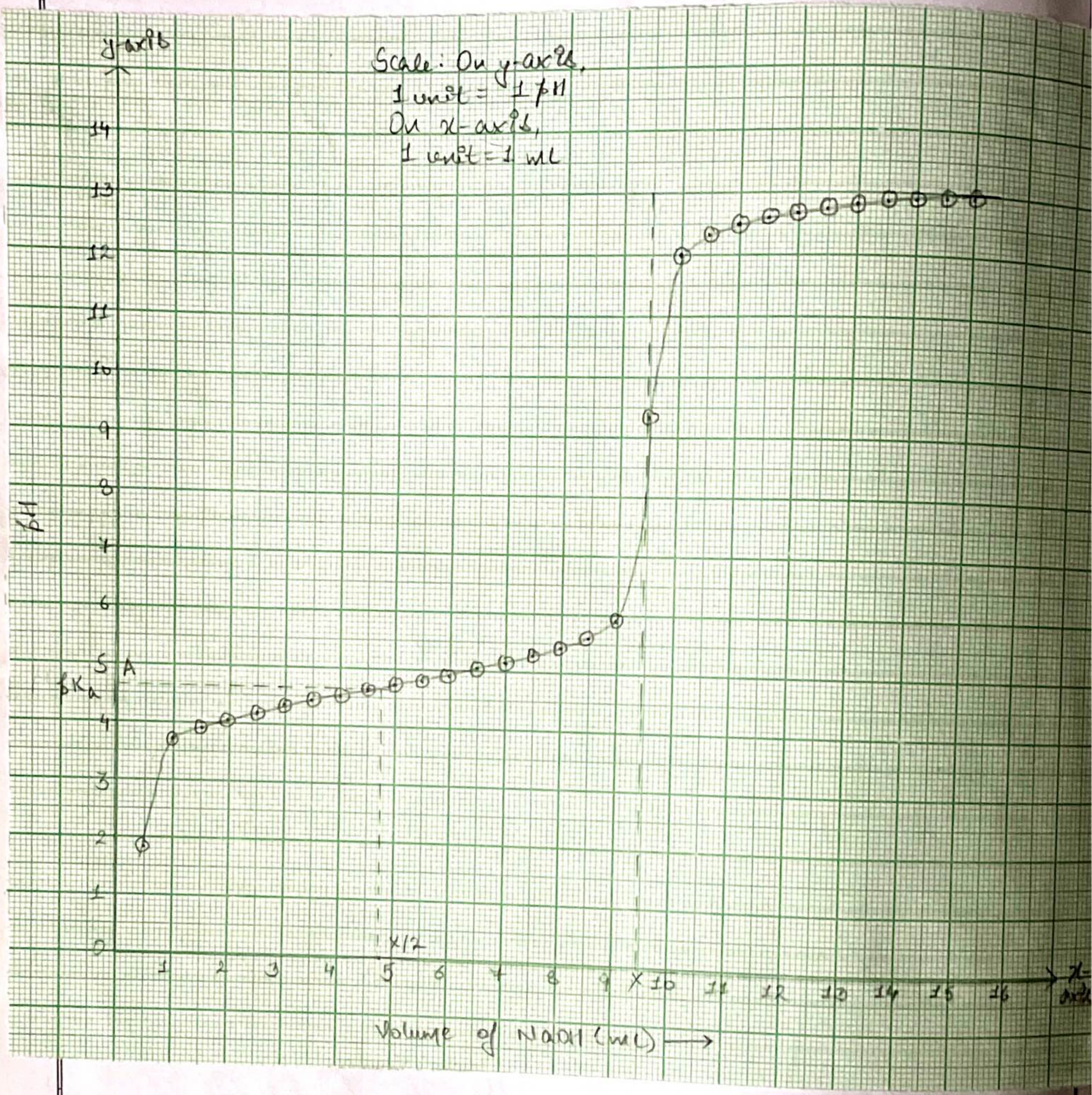
GRAPH:




RESULT: The $pK_a$ of acetic acid is 4.65.

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