Ambiguity in Determining the Source of OH^- Ions in Titration

Context

Consider the titration of a weak acid, acetic acid (CH_3COOH), with a strong base, sodium hydroxide (NaOH), using phenolphthalein as an indicator.

Observation

Phenolphthalein changes colour in the pH range of approximately 8.2 to 10. This means that the endpoint indicated by the colour change corresponds to a relatively basic pH.

Ambiguity Introduced by Indicator

Since the colour change occurs only at a high pH, we cannot determine from the indicator alone whether:

1. The basic pH is due to hydrolysis of the acetate ion (CH_3COO^-) formed at the equivalence point:

$$CH_3COO^- + H_2O \rightleftharpoons CH_3COOH + OH^-$$

2. Or the basic pH results from continued addition of NaOH beyond the equivalence point, contributing excess OH^- ions directly.

Conclusion

When using a high-pH indicator such as phenolphthalein, one cannot conclusively determine whether the observed OH^- at the endpoint is:

- Due to salt hydrolysis at the equivalence point, or
- Due to overshooting the equivalence point with excess base.

Therefore, to accurately determine the pH at equivalence and distinguish the source of OH^- ions, one should use a pH meter or construct a titration curve.