**Titration Curve – Equivalence Point pH Question**

**Question:** 20.00 mL of 0.320 mol L\(^{-1}\) ammonia, NH\(_3\), is titrated with 0.640 mol L\(^{-1}\) hydrochloric acid, HCl. 

\(pK_a(\text{NH}_4^+) = 9.24\) 

Show, by calculation, that the pH at the equivalence point (point C) is 4.96. 

\(K_w = 1 \times 10^{-14}\)

**Answer**

1. **Determine if equivalence point is greater or less than 7 (from curve or strong base/weak acid, strong acid/weak base).**

   - Ammonia, NH\(_3\), is weak base and hydrochloric acid, HCl, is strong acid so equivalence point <7.

2. **Write down neutralisation equation.**

   - \(\text{NH}_3 + \text{HCl} \rightarrow \text{NH}_4^+ + \text{Cl}^-\)

3. **Calculate \(n(\text{Base})\) to neutralise and reach equivalence point and therefore \(n(\text{Acid})\) from 1:1 equation.**

   - \(n(\text{NH}_3) = cv\)
   - \(n(\text{NH}_3) = 0.320 \text{ mol L}^{-1} \times 0.0200 \text{ L}\)
   - \(n(\text{NH}_3) = 6.40 \times 10^{-3} \text{ mol}\)

4. **Calculate \(v(\text{Acid})\) to neutralise \(n(\text{NH}_3) = n(\text{HCl})\) from 1:1 equation.**

   - \(v = \frac{n}{c}\)
   - \(v = 6.40 \times 10^{-3} \text{ mol} / 0.640 \text{ mol L}^{-1}\)
   - \(v = 0.0100 \text{ L} (10.0 \text{ mL})\)

5. **Calculate \([B^+]\) and assume \(n(B) = n(B^+)\) see step 3.**

   - \(c = \frac{n}{\text{total } v}\)
   - \(c = 6.40 \times 10^{-3} \text{ mol} / 0.0300 \text{ L}\)
   - \(c = 0.213 \text{ mol L}^{-1}\)

6. **Calculate \([\text{H}_3\text{O}^+]\).**

   - \([\text{H}_3\text{O}^+] = \sqrt{K_a \times c(B^+)}\)
   - \([\text{H}_3\text{O}^+] = \sqrt{10^{-9.24} \times 0.213 \text{ mol L}^{-1}}\)
   - \([\text{H}_3\text{O}^+] = 1.11 \times 10^{-5} \text{ mol L}^{-1}\)

7. **Calculate pH.**

   - \(pH = -\log[\text{H}_3\text{O}^+]\)
   - \(pH = -\log[1.11 \times 10^{-5} \text{ mol L}^{-1}]\)
   - \(pH = 4.96\)

**NOTE:** The white column is how your answer would appear on your test paper so make sure you write out complete sentences. The grey area is just to help you structure your answer and would not appear in the question.