

Chemistry 3.6 AS 91392 Demonstrate understanding of equilibrium principles in aqueous systems

Writing Excellence answers to Titration Curve – Equivalence Point pH questions

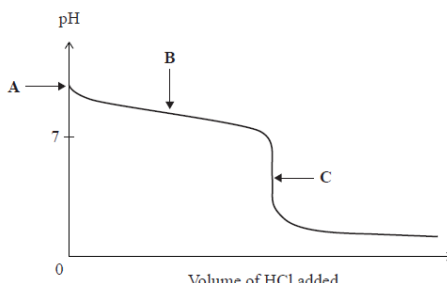
Titration Curve – Equivalence Point pH QUESTION

Question: 20.00 mL of 0.320 mol L⁻¹ ammonia, NH₃, 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.

$K_w = 1 \times 10^{-14}$



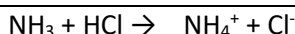
ANSWER

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

And write down all available information

ammonia, NH₃ is weak base and hydrochloric acid, HCl is strong acid so equivalence point < 7
 $v(\text{NH}_3) = 20.00 \text{ mL} = 0.0200 \text{ L}$
 $c(\text{NH}_3) = 0.320 \text{ mol L}^{-1}$
 $c(\text{HCl}) = 0.640 \text{ mol L}^{-1}$
 $pK_a(\text{NH}_4^+) = 9.24$

2. Write down neutralisation equation



3. calculate $n(\text{Base})$ to neutralise (and reach equivalence point and therefore $n(\text{Acid})$ from 1:1 equation)
 $n = cv$
 also assume $n(\text{NH}_3) = n(\text{NH}_4^+)$
 3sgf and units

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

4. calculate $v(\text{Acid})$ to neutralise ($n(\text{NH}_3) = n(\text{HCl})$ from 1:1 equation)
 $v = n/c$
 3sgf and units

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

5. calculate $[\text{B}^+]$
 $c = n/\text{total } v$
 also assume $n(\text{B}) = n(\text{B}^+)$ see step 3.
 $\text{B} = \text{NH}_3 \quad \text{B}^+ = \text{NH}_4^+$
 total $v = \text{start volume base} + v \text{ acid added}$
 3sgf and units

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

6. calculate $[\text{H}_3\text{O}^+]$
 $K_a = 10^{-pK_a}$
 $[\text{H}_3\text{O}^+] = \sqrt{K_a \times c(\text{B}^+)}$
 3sgf and units $\text{B}^+ = \text{HA}$

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

7. Calculate pH

$\text{pH} = -\log [\text{H}_3\text{O}^+]$

3sgf

Check pH against estimate on curve

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

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.