

Determination of the M_r of an Unknown Solid Acid using Titration (3A/ABT)

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1 Aim

To determine the M_r of an unknown solid acid (A) using a titrimetric method of analysis.

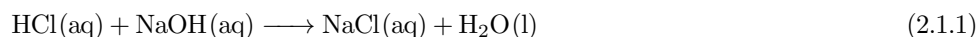
2 Results and Analysis

Batch of HCl used : B

Concentration of HCl : $0.1029 \text{ mol dm}^{-3}$

Batch of NaOH Used : B

2.1 Titration between NaOH and HCl



Phenolphthalein was used as the indicator (colour change from pink to colourless at the end point).

Table 1: Results from titrating 25.00 cm^3 of NaOH with HCl.

| Run | Start Volume / cm^3 | End Volume / cm^3 | Titre / cm^3 |
|-----|------------------------------|----------------------------|-----------------------|
| 1 | 6.60 | 30.95 | 24.35 |
| 2 | 2.00 | 25.85 | 23.85 |
| 3 | 4.20 | 28.30 | 24.10 |
| 4 | 4.45 | 28.55 | 24.10 |

$$\text{Average titre} = \frac{24.10 \text{ cm}^3 + 24.10 \text{ cm}^3}{2} = 24.10 \text{ cm}^3$$

$$\begin{aligned} \text{Moles of HCl in titre} &= 24.10 \text{ cm}^3 \times \left(\frac{1 \text{ dm}}{10 \text{ cm}}\right)^3 \times 0.1029 \text{ mol dm}^{-3} \\ &= 24.10 \times 10^{-3} \text{ dm}^3 \times 0.1029 \text{ mol dm}^{-3} \\ &= 2.480 \times 10^{-3} \text{ mol} \end{aligned}$$

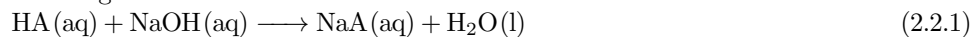
From equation 2.1.1 there is a 1:1 molar ratio between HCl and NaOH.

$$\therefore \text{Moles of NaOH in } 25.00 \text{ cm}^3 = 2.480 \times 10^{-3} \text{ mol}$$

$$\begin{aligned} \text{Concentration of NaOH} &= \frac{2.480 \times 10^{-3} \text{ mol}}{25.00 \text{ cm}^3 \times \left(\frac{1 \text{ dm}}{10 \text{ cm}}\right)^3} \\ &= \frac{2.480 \times 10^{-3} \text{ mol}}{25.00 \times 10^{-3} \text{ dm}^3} \\ &= 0.09920 \text{ mol dm}^{-3} \end{aligned}$$

2.2 Titration between NaOH and Unknown Acid A

For HA being the unknown acid A and assuming HA is monobasic:



Phenolphthalein was used as the indicator (colour change from pink to colourless at the end point).

A mass of 1.8525 g of HA was dissolved with distilled water in a 200.00 cm^3 volumetric flask.

$$\text{Average titre} = \frac{20.10 \text{ cm}^3 + 20.15 \text{ cm}^3}{2} = 20.13 \text{ cm}^3$$

Table 2: Results from titrating 20.00 cm³ of NaOH with HA.

| Run | Start Volume / cm ³ | End Volume / cm ³ | Titre / cm ³ |
|-----|--------------------------------|------------------------------|-------------------------|
| 1 | 4.00 | 24.90 | 20.90 |
| 2 | 4.00 | 24.10 | 20.10 |
| 3 | 4.05 | 24.20 | 20.15 |

$$\begin{aligned}
 \text{Moles of NaOH in } 20.00 \text{ cm}^3 \text{ aliquot} &= 20.00 \text{ cm}^3 \times \left(\frac{1 \text{ dm}}{10 \text{ cm}}\right)^3 \times 0.09920 \text{ mol dm}^{-3} \\
 &= 20.00 \times 10^{-3} \text{ dm}^3 \times 0.09920 \text{ mol dm}^{-3} \\
 &= 1.984 \times 10^{-3} \text{ mol}
 \end{aligned}$$

From equation 2.2.1 there is a 1:1 molar ratio between NaOH and HA.

$$\therefore \text{Moles of HA in } 20.13 \text{ cm}^3 = 1.984 \times 10^{-3} \text{ mol}$$

$$\begin{aligned}
 \text{Concentration of HA} &= \frac{1.984 \times 10^{-3} \text{ mol}}{20.13 \text{ cm}^3 \times \left(\frac{1 \text{ dm}}{10 \text{ cm}}\right)^3} \\
 &= \frac{1.984 \times 10^{-3} \text{ mol}}{20.13 \times 10^{-3} \text{ dm}^3} \\
 &= 0.09855 \text{ mol dm}^{-3}
 \end{aligned}$$

Hence for the whole 200.00 cm³ volumetric flask:

$$\begin{aligned}
 \text{Moles of HA} &= 0.09855 \text{ mol dm}^{-3} \times 200.00 \text{ cm}^3 \times \left(\frac{1 \text{ dm}}{10 \text{ cm}}\right)^3 \\
 &= 0.09855 \text{ mol dm}^{-3} \times 200.00 \times 10^{-3} \text{ dm}^3 \\
 &= 0.01971 \text{ mol}
 \end{aligned}$$

Since:

$$\begin{aligned}
 \text{Amount mol} &= \frac{\text{Mass g}}{M_r \text{ g mol}^{-1}} \\
 M_r \text{ g mol}^{-1} &= \frac{\text{Mass g}}{\text{Amount mol}}
 \end{aligned}$$

Hence:

$$M_r \text{ of HA} = \frac{1.8525 \text{ g}}{0.01971 \text{ mol}} = 93.98 \text{ g mol}^{-1}$$