

2

Key

Section A

Answer **all** questions. Write your answers in the boxes provided.

1. Ethanedioic acid is a diprotic acid. A student determined the value of x in the formula of hydrated ethanedioic acid, $\text{HOOC}-\text{COOH}\cdot x\text{H}_2\text{O}$, by titrating a known mass of the acid with a 0.100 mol dm^{-3} solution of $\text{NaOH}(\text{aq})$.

0.795 g of ethanedioic acid was dissolved in distilled water and made up to a total volume of 250 cm^3 in a volumetric flask. — 250.

25 cm^3 of this ethanedioic acid solution was pipetted into a flask and titrated against aqueous sodium hydroxide using phenolphthalein as an indicator.

The titration was then repeated twice to obtain the results below.

Volume of 0.100 mol dm^{-3} $\text{NaOH} / \text{cm}^3$	Titration 1	Titration 2	Titration 3
Final burette reading (± 0.05)	13.00	25.70	38.20
Initial burette reading (± 0.05)	0.00	13.00	25.70
Volume added	13.00	12.70	12.50

- (a) Calculate the average volume of NaOH added, in cm^3 , in titrations 2 and 3, and then calculate the amount, in mol, of NaOH added. [2]

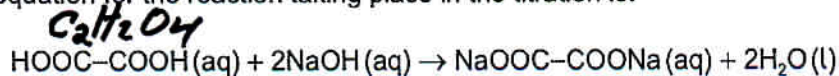
$$\begin{aligned} & (12.70 + 12.50) / 2 = 12.60\text{ cm}^3 \\ & 0.01260\text{ dm}^3 \times \frac{0.100\text{ mol}}{\text{dm}^3} = 0.00126\text{ mol} \end{aligned}$$

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(Question 1 continued)

- (b) (i) The equation for the reaction taking place in the titration is:



Determine the amount, in mol, of ethanedioic acid that reacts with the average volume of NaOH (aq). [1]

$$0.00126 \text{ mol NaOH} \times \frac{1 \text{ mol}}{2 \text{ mol NaOH}} = 6.30 \times 10^{-4} \text{ mol}$$

- (ii) Determine the amount, in mol, of ethanedioic acid present in 250 cm
- ³
- of the original solution. [1]

$$250. \text{ cm}^3 \times \frac{6.30 \times 10^{-4} \text{ mol}}{25 \text{ cm}^3} = 6.30 \times 10^{-3} \text{ mol}$$

- (iii) Determine the molar mass of
- hydrated
- ethanedioic acid. [1]

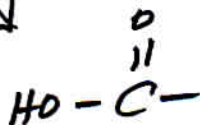
$$\frac{0.795 \text{ g}}{6.30 \times 10^{-3} \text{ mol}} = 126 \text{ g mol}^{-1}$$

- (iv) Determine the value of x in the formula HOOC-COOH·xH
- ₂
- O. [2]

$$\begin{aligned} M_r(\text{C}_2\text{H}_2\text{O}_4) &= 90.04 & M_r(\text{H}_2\text{O}) &= 18.02 \\ \text{mass H}_2\text{O} &= 126 - 90.04 = 35.96 \\ x &= \frac{35.96}{18.02} \approx 2 \end{aligned}$$

- (c) Identify the strongest intermolecular force in solid ethanedioic acid. [1]

Hydrogen bonds

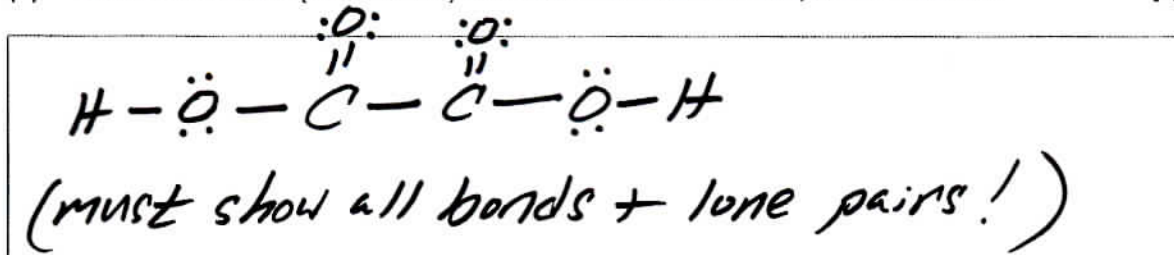


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(Question 1 continued)

(d) Deduce the Lewis (electron dot) structure of ethanedioic acid, HOOC-COOH. [1]



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(e) Predict and explain the difference in carbon-oxygen bond lengths in ethanedioic acid and its conjugate base, $^-\text{OOC}-\text{COO}^-$. [3]