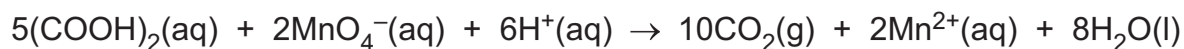


1 Hydrated ethanedioic acid is a diprotic acid with the formula $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$ where x is an integer.

Ethanedioic acid reacts with manganate(VII) ions when heated.



You will determine the value of x in $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$ by titrating a solution containing ethanedioic acid with manganate(VII) ions.

- **FA 1** is 6.20 g dm^{-3} aqueous ethanedioic acid, $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$.
- **FA 2** is $0.0200 \text{ mol dm}^{-3}$ potassium manganate(VII), KMnO_4 .
- **FA 3** is 1.0 mol dm^{-3} sulfuric acid, H_2SO_4 .

(a) Method

- Fill the burette with **FA 2**.
- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Use the measuring cylinder to add approximately 20 cm^3 of **FA 3** to the conical flask.
- Place the conical flask on a tripod and gauze and heat carefully until the temperature of the solution is approximately 70°C .
- Remove the flame.
- Carefully lift the hot conical flask and place it on the white tile under the burette.
- Add **FA 2** drop-wise for the first $2\text{--}3 \text{ cm}^3$. Any initial pink colouring may take several seconds to disappear.
- If the reaction mixture turns brown, reheat it to about 70°C . If the brown colour disappears, continue the titration. If the brown colour remains, discard the contents of the flask and begin a new titration.
- The end-point is reached when a permanent pale pink colour is formed.
- Perform a rough titration with **FA 2**. Record your burette readings in the space below.

The rough titre is cm^3 .

- Carry out as many titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record all your burette readings and the volume of **FA 2** added in each accurate titration.

Results

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b)** From your accurate titration results, calculate a suitable mean value to be used in your calculations.

Show clearly how you obtained this value.

25.0 cm^3 of **FA 1** required cm^3 of **FA 2**. [1]

(c) Calculations

- (i)** Give your answers to **(c)(ii)**, **(c)(iii)** and **(c)(iv)** to the appropriate number of significant figures. [1]

- (ii)** Calculate the amount, in mol, of manganate(VII) ions, MnO_4^- , in the volume of **FA 2** calculated in **(b)**.

amount of $\text{MnO}_4^- = \dots\dots\dots \text{ mol}$ [1]

- (iii)** Calculate the amount, in mol, of ethanedioic acid that reacts with the manganate(VII) ions in **(c)(ii)**.

amount of $(\text{COOH})_2 = \dots\dots\dots \text{ mol}$

Hence calculate the concentration, in mol dm^{-3} , of ethanedioic acid in **FA 1**.

concentration of $(\text{COOH})_2 = \dots\dots\dots \text{ mol dm}^{-3}$ [2]

- (iv)** Calculate the relative molecular mass, M_r , of the ethanedioic acid in **FA 1**.

$M_r = \dots\dots\dots$ [1]

- (v)** Calculate the value of x in $(\text{COOH})_2 \cdot x\text{H}_2\text{O}$.

Show your working.

$x = \dots\dots\dots$ [1]

- (d)** Explain why it is necessary to add **FA 3** in each titration.

.....
..... [1]