| Surname | Centre Number | Candidate Number |
|---|---|---|
| First name(s) | | 2 |

# GCE A LEVEL

1410U50-1A

S25-1410U50-1A

**WEDNESDAY, 7 MAY 2025**

## CHEMISTRY – A2 unit 5

### Practical Examination

## Experimental Task

### TEST 1

3 hours

| For Teacher's use only<br>Award a mark of 0 or 1<br>for each of the following | |
|---|---|
| Working safely **(Parts A & B)** | |
| Making up a solution **(Part A)** | |

| For Examiner's use only | |
|---|---|
| Mark Awarded | |
| **Total** | |

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01

**ADDITIONAL MATERIALS**

- A calculator, pencil and ruler
- **Data Booklet** supplied by WJEC

**INSTRUCTIONS TO CANDIDATES**

Use black ink or black ball-point pen. You may use a pencil for graphs and diagrams only.
Write your name, centre number and candidate number in the spaces at the top of this page.
Write your answers in the spaces provided in this booklet.

**INFORMATION FOR CANDIDATES**

The total number of marks available for this task is 30.
Your teacher will directly assess your practical skills in **Parts A** and **B**.
The number of marks is given in brackets at the end of each question or part-question.
You are reminded of the necessity for orderly presentation in your answers.

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**This practical examination is in two parts:**

**Part A – Determine the molar mass of ethanedioic acid and hence the value of $x$ in $(COOH)_2.xH_2O$**

Ethanedioic acid is a common industrial cleaner, often used to remove corrosion from metal surfaces. It is usually bought in the form of a hydrated salt – $(COOH)_2.xH_2O$.

In order to prepare a solution of known concentration, the value of $x$ must be found.

A solution of sodium hydroxide is standardised by titrating against hydrochloric acid of known concentration. Ethanedioic acid is then titrated against the standardised sodium hydroxide solution to find its molar mass and hence the value of $x$.

**Part B – Qualitative organic tests on the reaction mixture at each stage of the production of ethanedioic acid**

Ethanedioic acid is produced from ethene in a three-step process.

$$C_2H_4 \xrightarrow{\text{step 1}} ClCH_2CH_2Cl \xrightarrow{\text{step 2}} HOCH_2CH_2OH \xrightarrow{\text{step 3}} (COOH)_2$$

A series of tests is carried out to identify one of the functional groups present in the reaction mixture at each stage of the process.

Record all observations in the spaces provided and then use the results in the analysis section later in the paper.

The apparatus and chemicals required are listed on the following pages.

**Part A – Determine the molar mass of ethanedioic acid and hence the value of $x$ in $(COOH)_2.xH_2O$**

**Apparatus**

Note that ethanedioic acid is toxic and appropriate care should be taken when handling the solid and the solution.

You will need eye protection, gloves and the following apparatus:

1 × weighing bottle + lid containing approximately 2.0 g of $(COOH)_2.xH_2O$ (toxic)
2 × 100 $cm^3$ beaker
1 × large funnel (to transfer ethanedioic acid solution to volumetric flask)
1 × stirring rod
1 × 25 $cm^3$ measuring cylinder
1 × 250 $cm^3$ volumetric flask
1 × wash bottle containing deionised water
1 × 50 $cm^3$ burette
1 × burette stand
1 × small funnel (to fill burette)
2 × 25 $cm^3$ volumetric pipette
1 × pipette filler
2 × 250 $cm^3$ conical flask
1 × plastic dropping pipette

Ready access to a weighing balance

**Chemicals**

In addition to approximately 2.0 g of $(COOH)_2.xH_2O$ in the weighing bottle, you will need:

approximately 200 $cm^3$ of approximately 0.15 mol $dm^{-3}$ hydrochloric acid solution, HCl(aq) (irritant)
approximately 200 $cm^3$ of sodium hydroxide solution, NaOH(aq), of unknown concentration (irritant)
phenolphthalein indicator (flammable)
deionised water

You will be told the **exact concentration** of the hydrochloric acid solution by your teacher.

**Record this on page 10.**

**Part B – Qualitative organic tests on the reaction mixture at each stage of the production of ethanedioic acid**

**Apparatus**

You will need eye protection and the following apparatus:

4 × plastic dropping pipette
1 × test tube rack
1 × spatula

**Chemicals**

You will need:

1 × stoppered test tube labelled **1**, containing approximately 3 $cm^3$ of reaction mixture from step 1
1 × stoppered test tube labelled **2**, containing approximately 3 $cm^3$ of reaction mixture from step 2
1 × stoppered test tube labelled **3**, containing approximately 3 $cm^3$ of reaction mixture from step 3

deionised water
approximately 10 $cm^3$ of 1 mol $dm^{-3}$ nitric acid solution, $HNO_3(aq)$ (corrosive)
approximately 2 $cm^3$ of 0.1 mol $dm^{-3}$ silver nitrate solution, $AgNO_3(aq)$ (irritant)
approximately 5 $cm^3$ of 1 mol $dm^{-3}$ sodium hydroxide solution, NaOH(aq) (corrosive)
approximately 1 g of solid sodium carbonate, $Na_2CO_3(s)$ (irritant)
approximately 2 $cm^3$ of 0.002 mol $dm^{-3}$ acidified potassium manganate(VII), $KMnO_4 / H^+(aq)$ (irritant)

**Part A – Determine the molar mass of ethanedioic acid and hence the value of $x$ in $(COOH)_2.xH_2O$**

You will standardise a solution of sodium hydroxide by titrating against hydrochloric acid of known concentration. You will then make up a solution of ethanedioic acid and titrate this against the standardised sodium hydroxide solution. From your results you will calculate the molar mass of the hydrated ethanedioic acid and hence the value of $x$.

**Procedure**

- **Wear eye protection at all times and gloves when handling toxic ethanedioic acid**
- **Assume that all solutions are toxic and corrosive**

**Standardising sodium hydroxide solution using hydrochloric acid of known concentration**

1. Draw an appropriate table on page 7 to record the results of your titration.
2. Fill a burette with the sodium hydroxide solution provided and record the initial burette reading.
3. Use a volumetric pipette to transfer 25.0 $cm^3$ of hydrochloric acid to the conical flask.
4. Add a few drops of phenolphthalein indicator and titrate until a permanent colour change is seen.
5. Record the final burette reading and the titre.
6. Wash the conical flask and rinse with deionised water. Repeat the titration until you have **two** concordant titre values (within a range of 0.20 $cm^3$).

   **As a guideline, the accurate titres should lie between 15 $cm^3$ and 25 $cm^3$.**
7. Calculate the mean titre. Show clearly which values you have selected to carry out the calculation.

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Examiner only

**Making up a solution of ethanedioic acid**

8. Weigh the weighing bottle containing $(COOH)_2.xH_2O$ and record the mass below.

9. Transfer the contents to the beaker and reweigh the bottle and lid.

10. Record the mass below and calculate the exact mass of $(COOH)_2.xH_2O$ transferred to the beaker.

11. Add about 50 $cm^3$ of deionised water to the solid in the beaker and stir to dissolve.

12. Transfer the solution to the volumetric flask. Make sure that all the washings are transferred.

13. Make the solution in the flask up to the mark with deionised water. Use the plastic dropping pipette to add the last few drops.

14. Put the stopper in the flask and invert a few times to ensure that the solution is completely mixed.

**Weighing data**

Mass of weighing bottle, lid and $(COOH)_2.xH_2O$ = ..... g

Mass of empty weighing bottle and lid = ..... g

Mass of $(COOH)_2.xH_2O$ = ..... g

**Titrating ethanedioic acid with standardised sodium hydroxide**

15. Draw an appropriate table on page 7 to record the results of your titration.

16. Repeat steps 2–6 (on page 5) using the ethanedioic acid solution in place of hydrochloric acid.

    **As a guideline, the accurate titres should lie between 12 $cm^3$ and 20 $cm^3$.**

17. Calculate the mean titre. Show clearly which values you have selected to carry out the calculation.

Use your results in the **Analysis of Results** section after you have completed **Part B** of the Experimental Task.

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**Results Sheet**

**Part A – Determine the molar mass of ethanedioic acid and hence the value of $x$ in $(COOH)_2.xH_2O$**

Draw your results tables in the spaces below. Make sure that you include titles and units and that you record your data to the appropriate number of decimal places.

**Standardising sodium hydroxide solution using hydrochloric acid of known concentration**

Mean titre = ..... $cm^3$

**Titrating ethanedioic acid with standardised sodium hydroxide**

Mean titre = ..... $cm^3$

**Examiner only**

| | |
|---|---|
| **Results – recording** | |

[4]

| | |
|---|---|
| **Results – accuracy** | |

[6]

**Part B – Qualitative organic tests on the reaction mixture at each stage of the production of ethanedioic acid**

Ethanedioic acid is produced from ethene in a three-step process.

$$C_2H_4 \xrightarrow{\text{step 1}} ClCH_2CH_2Cl \xrightarrow{\text{step 2}} HOCH_2CH_2OH \xrightarrow{\text{step 3}} (COOH)_2$$

The contents of test tubes **1**, **2** and **3** represent the organic compounds present **after** steps 1, 2 and 3.

The tests carried out provide evidence of the identity of the functional group in one of the compounds present after each reaction.

Carry out the tests below and record your observations in the table on page 9. For each of the tests, if there is no apparent change, you should write 'no observable change'.

You are **not** required to identify the functional groups present until the **Analysis of Results** section.

**Procedure**

- **Wear eye protection at all times**
- **Assume that all substances are toxic and corrosive**

**Test tube 1**

1. Add a few drops of acidified potassium manganate(VII).

2. Replace the stopper, shake gently and allow to stand for a few minutes.

**Test tube 2**

1. Add approximately 4 $cm^3$ of sodium hydroxide.

2. Replace the stopper, shake gently and allow to stand for a few minutes.

3. Add approximately 8 $cm^3$ of nitric acid and again shake gently.

4. Add a few drops of silver nitrate solution.

**Test tube 3**

1. Add approximately half a spatula of solid sodium carbonate.

   **Do not replace the stopper in this tube.**

Examiner only

**Part B – Qualitative organic tests on the reaction mixture at each stage of the production of ethanedioic acid**

Record your observations in the table.

| | **Observation(s)** |
|---|---|
| **Test tube 1** | |
| **Test tube 2** | |
| **Test tube 3** | |

Use these observations in the **Analysis of Results** section.

**Examiner only**

| | |
|---|---|
| **Results – observations** | |

[3]

Examiner only

**Analysis of Results**

**Results for Part A – Determine the molar mass of ethanedioic acid and hence the value of $x$ in $(COOH)_2.xH_2O$**

Exact concentration of hydrochloric acid solution = ..... mol dm$^{-3}$
(provided by your teacher)

(i) Use the mean titre from the titration of hydrochloric acid and sodium hydroxide to calculate the concentration of the sodium hydroxide solution. [2]

Concentration = ..... mol dm$^{-3}$

(ii) Use your answer to part (i) and the following equation to calculate the number of moles of $(COOH)_2$ in the 250 cm$^3$ volumetric flask. [3]

$$2NaOH + (COOH)_2 \longrightarrow Na_2(COO)_2 + 2H_2O$$

Number of moles = ..... mol

Examiner only

(iii) Use your answer to part (ii) and the mass of solid hydrated ethanedioic acid transferred to the beaker to calculate the molar mass of $(COOH)_2.xH_2O$ and hence the value of $x$. Give your answer to 1 decimal place. [2]

$x$ = .....

(iv) Briefly explain why ethanedioic acid is soluble in water. [2]

.....

.....

.....

Examiner only

**Part B – Qualitative organic tests on the reaction mixture at each stage of the production of ethanedioic acid**

(v) Use your results from page 9 to explain what the observations tell you about the composition of the reaction mixture after each step. [3]

Step 1

.....

.....

Step 2

.....

.....

Step 3

.....

.....

(vi) A student suggested that using IR spectroscopy would be a better way to monitor the progress of the reactions.

Use the **Data Booklet** to suggest how the IR spectrum of the reaction mixture would change as the reaction in each step progresses. [3]

Step 1

.....

.....

Step 2

.....

.....

Step 3

.....

.....

**END OF PAPER**