Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

1410U50-1A

S23-1410U50-1A

WEDNESDAY, 10 MAY 2023

CHEMISTRY – A2 unit 5

Practical Examination

Experimental Task

TEST 1

3 hours

For Teacher's use only Award a mark of 0 or 1 for each of the three areas below	
Making up a solution **(Part A)**	
Efficient use of time **(Part B)**	
Working safely **(Parts A & B)**	

For Examiner's use only	
Mark Awarded	
Total	

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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.

This practical examination is in two parts:

Part A – Quantitative analysis of "Hard Water"

A back titration to analyse the content of a solid mixture of calcium carbonate and magnesium carbonate obtained from a sample of hard water.

Part B – Qualitative analysis of "Hard Water"

A series of inorganic tests to confirm the efficiency of an ion-exchange process carried out on a sample of hard water containing calcium ions.

You should record all observations in the spaces provided and then use the results in the analysis section later in this paper.

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

Part A – Quantitative analysis of "Hard Water"

Apparatus

You will need eye protection and the following apparatus:

1 × weighing bottle + lid containing approximately 3.00 g of a solid mixture of calcium carbonate powder ($CaCO_3$) and magnesium carbonate powder ($MgCO_3$) (labelled X)
2 × 50 cm^3 burette
1 × 25 cm^3 pipette
1 × 250 cm^3 standard (volumetric) flask
2 × 250 cm^3 conical flask
1 × 250 cm^3 beaker
3 × filter funnel
1 × spatula
1 × stirring rod
1 × wash bottle (deionised water)
1 × burette stand
1 × pipette filler
1 × white tile
2 × graduated plastic pipette

Ready access to ideally a 3 decimal place weighing balance (although 2 d.p. is acceptable)

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Chemicals

You will need:

approximately 150 cm^3 of 0.20 mol dm^{-3} sodium hydroxide solution (NaOH) (harmful)
approximately 100 cm^3 of 2.0 mol dm^{-3} hydrochloric acid solution (HCl) (harmful)
phenolphthalein indicator (flammable)
deionised water

You will be given the **exact concentrations** of the NaOH and HCl solutions.

You will need to record these concentrations on page 10.

Part B – Qualitative analysis of "Hard Water"

Apparatus

You will need eye protection and the following apparatus:

1 × 100 cm^3 beaker containing approximately 1 g of a white solid (Y) which has been obtained from a sample of hard water containing calcium ions following the ion exchange process

1 × 25 cm^3 measuring cylinder

2 × graduated plastic pipette

2 × boiling tube

1 × boiling tube rack

1 × Bunsen burner

1 × damp splint

sticky labels or marker pen

Chemicals

You will need:

approximately 20 cm^3 of 1 mol dm^{-3} nitric acid solution (HNO_3) (harmful)
approximately 10 cm^3 of 0.1 mol dm^{-3} sodium hydroxide solution (NaOH) (harmful)
approximately 10 cm^3 of 0.1 mol dm^{-3} sodium sulfate solution (Na_2SO_4) (harmful)

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Part A – Quantitative analysis of "Hard Water"

A sample of water is deemed to be hard if it has a high mineral content – usually Ca^{2+} and Mg^{2+} ions.

Hard water is formed when water passes over deposits of limestone, largely made up of calcium carbonate and magnesium carbonate. Although hard water has some health benefits, it can pose some problems in industry. Water hardness has to be monitored to avoid breakdowns in any kind of equipment that handles water. In the home, hard water can be identified by a lack of foam formation when soap is mixed with water, and by the formation of limescale in kettles. Wherever water hardness is a concern, water softening is commonly used to reduce hard water's adverse effects.

A water sample with a Ca^{2+} ion concentration of greater than 50 mg/dm^3 is considered to be hard water.

In an attempt to analyse if a sample of water is deemed to be hard, 10 dm^3 was heated to dryness. The white solid obtained contains a mixture of calcium carbonate and magnesium carbonate. It can be analysed for the mineral content by the following procedure.

Procedure

- **Wear eye protection at all times**
- **Assume that all chemicals are toxic and corrosive**
- **Be especially careful when filling the burette with 2.0 mol dm^{-3} hydrochloric acid solution (HCl)**

1. Accurately weigh the weighing bottle containing solid X (and lid).

2. Transfer the solid to the 250 cm^3 beaker and re-weigh the bottle and lid.

3. Carefully add exactly 50.0 cm^3 of 2.0 mol dm^{-3} hydrochloric acid solution to the beaker using a burette. Allow the sample to react until the effervescence stops.

4. Carefully pour the contents of the beaker into the standard (volumetric) flask using a funnel.

5. Rinse the beaker and the funnel with deionised water and ensure that all washings are transferred into the flask.

6. Make the volume up to the mark on the flask using deionised water.

7. Pipette 25.0 cm^3 of the solution into a clean conical flask and add a few drops of phenolphthalein indicator.

8. Fill a burette with 0.20 mol dm^{-3} sodium hydroxide solution and titrate until the indicator changes colour. Record your initial and final volumes and the titre obtained in a table of your own design.

9. Repeat the titration until two concordant titres are obtained. Do not carry out more than five titrations. Alert your teacher if you do not have concordant results and they will advise you which two results to choose.

Record your results clearly on page 7.

You will use your results in the **Analysis of Results** section after you have completed **Part B** of this experimental task.

Examiner only

Results Sheet for Part A – Quantitative analysis of "Hard Water"

Weighing data

Mass of solid X, weighing bottle and lid	g
Mass of weighing bottle and lid	g
Mass of solid X	g

Titration data

Draw your own table to record all burette readings and titre values. Record your mean titre below.

Mean titre = ... **cm^3**

Examiner only

Mark Awarded for Titration Recording	

[5]

Expected titre (based on teacher values)	**cm^3**
Mark awarded	

[5]

Part B – Qualitative analysis of "Hard Water"

Hardness can be eliminated using an ion exchange system. This process replaces one Ca^{2+} ion with two Na^{+} ions. As sodium compounds are generally more soluble than calcium ones, this eliminates the properties usually associated with hard water.

However, to check that the Ca^{2+} ions have been removed and replaced by Na^{+} ions, the following qualitative tests are carried out on the solid obtained by heating to dryness a water sample passed through an ion exchange system.

Procedure

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

Flame test

1. Place a damp splint in the beaker to collect a sample of white solid Y.
2. Hold the splint in a roaring Bunsen burner flame.
3. Record any flame colour seen.

Reaction with dilute nitric acid

1. Use a measuring cylinder to add approximately 20 cm^3 of dilute nitric acid to solid Y in the beaker.
2. Record your observation(s).
3. Allow to stand for a few minutes and pour one half of the solution into one boiling tube and the other half into another boiling tube.

Reaction with sodium hydroxide solution

1. Use a graduated plastic pipette to add about 2 cm^3 of sodium hydroxide solution to one of the boiling tubes.
2. Record your observation(s).

Reaction with sodium sulfate solution

1. Use a graduated plastic pipette to add about 2 cm^3 of sodium sulfate solution to the other boiling tube.
2. Record your observation(s).

Record your results clearly on page 9.

You will use your results in the **Analysis of Results** section.

Examiner only

Results Sheet for Part B – Qualitative analysis of "Hard Water"

Record your observations in the table.

Test	Observation(s)
flame test	
nitric acid	
sodium hydroxide solution	
sodium sulfate solution	

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

Examiner only

Mark awarded	

[3]

Examiner only

Analysis of Results

Part A – Quantitative analysis of "Hard Water"

Concentration of HCl provided	**mol dm^{-3}**
Concentration of NaOH provided	**mol dm^{-3}**

(i) Calculate the number of moles of sodium hydroxide in your mean titre, and, subsequently, the number of moles of unreacted hydrochloric acid in the 25.0 cm^3 volume. [1]

(ii) State the number of moles of unreacted hydrochloric acid in the 250 cm^3 volumetric flask. [1]

(iii) Use the answer to part (ii) to calculate the number of moles of hydrochloric acid that reacted and hence the number of moles of carbonate ions in the original sample obtained from hard water. [2]

Examiner only

(iv) If the molar ratio of the magnesium and calcium compounds present in the original solid sample X was 1:2 respectively, calculate the mass of calcium carbonate present. [2]

(v) Consider the earlier reference:

"…a sample of water is deemed to be hard if the concentration of calcium ions exceeds 50 mg/dm^3…".

Use the answer to (iv) to determine the mass of calcium in the original sample obtained from 10 dm^3 of hard water, and, thus, the concentration in mg/dm^3. Then use the above reference to determine whether the original sample was indeed hard water. [2]

Examiner only

Part B – Qualitative analysis of "Hard Water"

(vi) Use **two** observations to explain if the ion-exchange process has worked on the sample provided. [4]

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(vii) One of the tests does not provide any useful information. Explain why this is so. [1]

(viii) Explain why during the ion-exchange process two sodium ions replace each calcium ion. [1]

END OF PAPER