Chemistry

Higher Level

Paper 1B — Mock Examination

Mock Exam 3

Calculator required

Time allowed: **55 minutes**

Maximum mark: **35 marks**

Candidate information

Candidate name: .....

Session number: .....

Date: .....

Topic emphasis: gravimetric determination of the formula of a hydrated salt, identification of an unknown organic compound using mass spectrometry, infrared spectroscopy, ^{1}H NMR and thin-layer chromatography, and quantitative electrolysis. Data processing, uncertainties, and the evaluation of experimental method are assessed throughout.

Instructions to candidates

- Write your session number in the box on the cover.
- Do not open this examination paper until you are told to do so.
- Answer **all** questions.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- A clean copy of the **chemistry data booklet** is required for this paper.
- The maximum mark for this examination paper is **[35 marks]**.

The mark allocation is shown in square brackets at the end of each question or part question. Where a numerical answer is required, values of constants and molar masses should be taken from the chemistry data booklet unless they are given in the question. Take the Faraday constant to be $F = 9.65 \times 10^4$ C mol^{-1}.

Mark allocation

Question 1 (gravimetric analysis)	[10 marks]
Question 2 (identification of an unknown)	[13 marks]
Question 3 (quantitative electrolysis)	[12 marks]
Total	**[35 marks]**

Section B

*Answer **all** questions. Answers must be written within the answer boxes provided.*

1. A student determined the value of x in hydrated magnesium sulfate, $MgSO_4 \cdot x\,H_2O$, by heating a sample in a crucible until all the water of crystallization had been driven off. All masses were measured on a balance reading to ± 0.001 g.

Data for the dehydration of $MgSO_4 \cdot x\,H_2O$	
Mass of empty crucible / g	24.352
Mass of crucible + hydrated salt / g	27.812
Mass of crucible + residue after heating / g	26.041

(a) Calculate the mass of water lost and the mass of anhydrous magnesium sulfate formed. **[2]**

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(b) Determine the value of x, showing your working. **[3]**

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(c) Calculate the percentage uncertainty in the mass of water lost. **[2]**

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(Question 1 continued)

(d) The instructions state that the sample must be heated to constant mass. Explain why this is necessary. **[1]**

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(e) Deduce the effect on the calculated value of x if some of the anhydrous salt spat out of the crucible during heating. **[2]**

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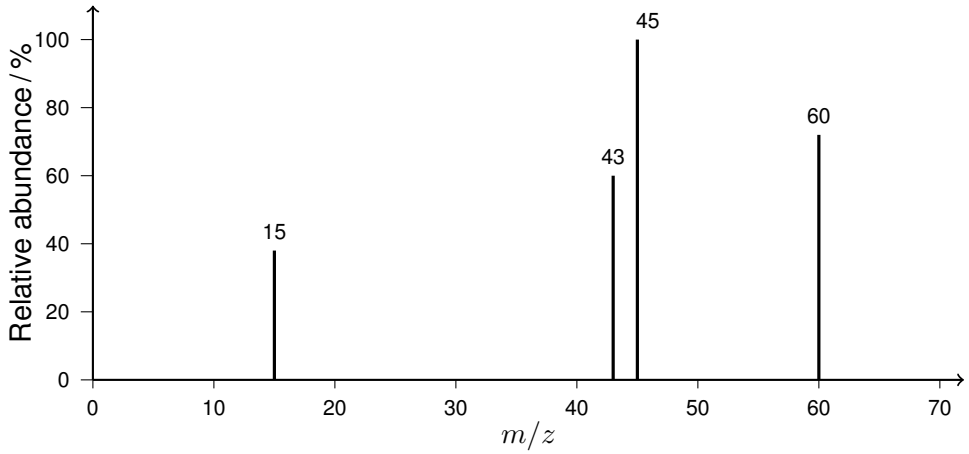
2. A colourless liquid, **X**, with a sharp odour was isolated from a reaction mixture. Its mass spectrum is shown below.



The infrared spectrum of **X** showed a very broad absorption from 2500 to 3200 cm^{-1} and a strong sharp absorption at 1710 cm^{-1}.

The ^1H NMR spectrum of **X** showed two signals, at δ 2.1 and δ 11.4, with an integration ratio of 3 : 1.

(a) Deduce the relative molecular mass of **X** from the mass spectrum. **[1]**

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(b) Identify the **two** bonds responsible for the infrared absorptions described above, using section 20 of the data booklet. **[2]**

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(c) Deduce the structural formula of **X**, using all of the evidence above. **[2]**

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(Question 2 continued)

(d) Identify the species responsible for the peaks at m/z = 45 and m/z = 15. **[2]**

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(e) **X** was spotted alongside a known reference compound, **Y**, on a thin-layer chromatography plate. The solvent front travelled 8.5 cm from the start line, **X** travelled 3.4 cm and **Y** travelled 6.8 cm.
Calculate the retardation factor, R_F, of each compound. **[2]**

R_F of **X**: . . . . . .

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R_F of **Y**: . . . . . .

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(f) The stationary phase was polar silica gel and the mobile phase was a non-polar solvent. Deduce, with a reason, which of **X** and **Y** is more polar. **[2]**

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(g) **X** was obtained as an aqueous mixture. State the technique that should be used to separate **X** from water, and explain why simple distillation would be unsuitable. **[2]**

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3. A student electroplated a steel spoon with copper by electrolysing aqueous copper(II) sulfate. A steady current of 0.500 A was passed for 30.0 minutes using a copper anode.

(a) Describe how the electrodes and the power supply should be connected, and state which electrode the spoon must be. **[2]**

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(b) Deduce the half-equation for the reaction occurring at the cathode. **[1]**

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(c) Determine the mass of copper that should be deposited on the spoon. **[3]**

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(d) The measured increase in the mass of the spoon was 0.281 g. Calculate the percentage error in this result.

If you did not obtain an answer to part (c), use 0.310 g although this is not the correct answer. **[2]**

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(Question 3 continued)

(e) Suggest **one** reason, other than a measurement error, why the mass deposited was less than the calculated value. **[1]**

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(f) Deduce the effect on the mass deposited if the current were doubled and the time halved. **[1]**

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(g) Explain why the blue colour of the electrolyte does not fade during this experiment. **[1]**

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(h) State **one** health and safety consideration for this experiment. **[1]**

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End of examination.

Total: 35 marks