# Chemistry

## Higher Level

Paper 1B — Mock Examination

# Mock Exam 1

Calculator required

Time allowed: **55 minutes**

Maximum mark: **35 marks**

### Candidate information

Candidate name: .....

Session number: .....

Date: .....

Topic emphasis: preparation of standard solutions and volumetric analysis, thermochemical measurement by calorimetry, and quantitative spectroscopic analysis using the Beer–Lambert relationship. 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. Unless otherwise stated, all measurements were made at 298 K and 100 kPa.

## Mark allocation

| | |
|---|---|
| Question 1 (volumetric analysis) | [13 marks] |
| Question 2 (calorimetry) | [11 marks] |
| Question 3 (colorimetry) | [11 marks] |
| **Total** | **[35 marks]** |

## Section B

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

**1.** A student determined the concentration of ethanoic acid, $CH_3COOH$, in a sample of commercial vinegar. The student first prepared a standard solution of anhydrous sodium carbonate, $Na_2CO_3$, and used it to standardize a solution of hydrochloric acid.

(a) Calculate the concentration, in $mol\,dm^{-3}$, of the standard solution prepared by dissolving 1.325 g of anhydrous sodium carbonate in water and making the solution up to 250.0 $cm^3$. **[1]**

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(b) Explain why anhydrous sodium carbonate is a suitable primary standard, whereas solid sodium hydroxide is not. **[2]**

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(c) The table shows the burette readings obtained when 25.00 $cm^3$ of the sodium carbonate solution was titrated with the hydrochloric acid.

| **Reading** | **Titration 1** |
|---|---|
| Initial burette reading / $cm^3$ | 0.05 |
| Final burette reading / $cm^3$ | 24.15 |
| Volume delivered / $cm^3$ | |

Complete the table and determine the concentration of the hydrochloric acid, using the equation below. **[2]**

$$Na_2CO_3(aq) + 2\,HCl(aq) \longrightarrow 2\,NaCl(aq) + H_2O(l) + CO_2(g)$$

Concentration: . . . . . .

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**(This question continues on the following page)**

**(Question 1 continued)**

(d) Each burette reading has an uncertainty of $\pm 0.05\,cm^3$. Calculate the percentage uncertainty in the volume delivered in part (c). **[2]**

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(e) A $20.00\,cm^3$ portion of a sodium hydroxide solution required $19.30\,cm^3$ of the standardized hydrochloric acid for complete neutralization. Determine the concentration of the sodium hydroxide solution.

If you did not determine a concentration in part (c), use $0.1150\,mol\,dm^{-3}$ although this is not the correct answer. **[1]**

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(f) A $25.00\,cm^3$ sample of the vinegar was transferred to a $250.0\,cm^3$ volumetric flask and made up to the mark with distilled water. A $25.00\,cm^3$ portion of this diluted vinegar required $24.60\,cm^3$ of the standardized sodium hydroxide solution.

Determine the concentration of ethanoic acid in the **original** vinegar.

If you did not determine a concentration in part (e), use $0.1200\,mol\,dm^{-3}$ although this is not the correct answer. **[2]**

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(g) The density of the vinegar is $1.01\,g\,cm^{-3}$. Calculate the percentage by mass of ethanoic acid in the vinegar. **[2]**

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(h) State the name of a suitable indicator for the titration in part (f), using section 18 of the data booklet, and give a reason for your choice. **[1]**

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**2.** A student determined the enthalpy of combustion of ethanol, $C_2H_5OH$, by burning it in a spirit burner beneath a copper calorimeter containing water. The results are shown in the table.

| **Data for the combustion of ethanol** | |
|---|---|
| Mass of water in the calorimeter / g ($\pm$0.1) | 150.0 |
| Initial temperature of the water / °C ($\pm$0.1) | 21.4 |
| Final temperature of the water / °C ($\pm$0.1) | 45.6 |
| Mass of spirit burner before burning / g ($\pm$0.01) | 182.45 |
| Mass of spirit burner after burning / g ($\pm$0.01) | 180.72 |

(a) Determine the energy, in kJ, absorbed by the water, using sections 1 and 2 of the data booklet. **[2]**

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(b) Determine the enthalpy of combustion of ethanol, in kJ mol$^{-1}$, including its sign.

If you did not obtain an answer to part (a), use 14.5 kJ although this is not the correct answer. **[2]**

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(c) The literature value for the enthalpy of combustion of ethanol is $-1367\,\text{kJ}\,\text{mol}^{-1}$. Calculate the percentage error in the student's value. **[1]**

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**(This question continues on the following page)**

**(Question 2 continued)**

(d) Calculate the percentage uncertainty in the mass of ethanol burned, and hence deduce whether random uncertainty alone can account for the difference between the student's value and the literature value. **[2]**

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(e) Deduce **two** sources of systematic error in this experiment, based on the direction of the error identified in part (c). **[2]**

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(f) Suggest **one** modification to the apparatus that would bring the experimental value closer to the literature value. **[1]**

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(g) The literature value is obtained using a bomb calorimeter. State **one** reason why this apparatus gives a more accurate result. **[1]**

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**3.** The concentration of aqueous copper(II) sulfate can be determined using a colorimeter. A student prepared five standard solutions of $Cu^{2+}(aq)$ and measured the absorbance of each.

| Concentration of $Cu^{2+}$ / mol dm$^{-3}$ | 0.0200 | 0.0400 | 0.0600 | 0.0800 | 0.1000 |
|---|---|---|---|---|---|
| Absorbance ($\pm$0.01) | 0.21 | 0.40 | 0.62 | 0.79 | 1.00 |

(a) Aqueous copper(II) sulfate is blue. Explain why a red filter, of wavelength 635 nm, was selected for these measurements. **[1]**

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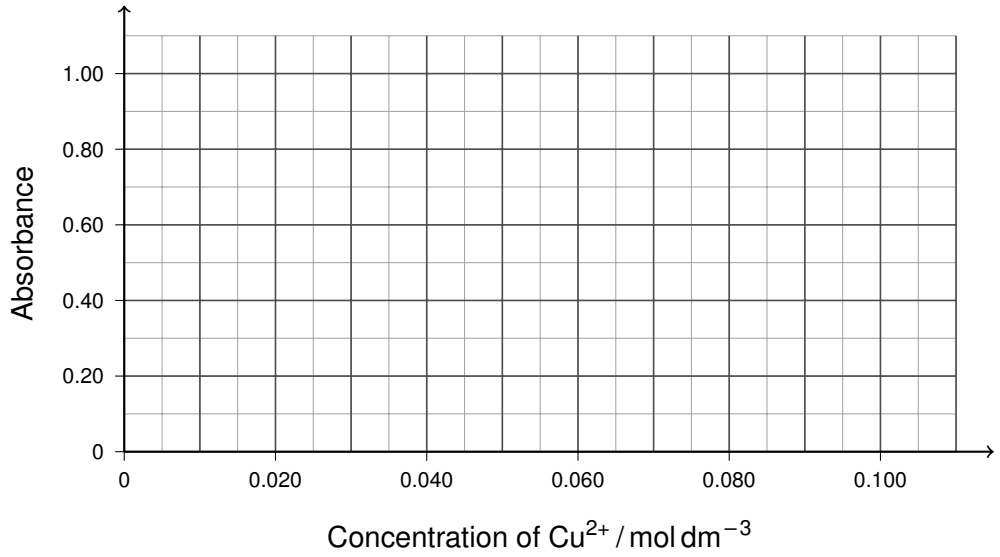
(b) Plot the data on the grid below and draw a straight line of best fit through the points and the origin. **[1]**




(c) Determine the gradient of your line of best fit, giving its units. **[2]**

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**(This question continues on the following page)**

**(Question 3 continued)**

(d) A solution of unknown concentration gave an absorbance of 0.52 under the same conditions. Determine its concentration.

If you did not determine a gradient in part (c), use $8.00\,dm^3\,mol^{-1}$ although this is not the correct answer. **[1]**

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(e) The student did not wipe fingerprints from the outside of the cuvette before measuring the unknown solution. Deduce the effect of this on the calculated concentration, and state whether the error is random or systematic. **[2]**

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(f) A second unknown solution gave an absorbance of 1.85, which lies outside the range of the calibration curve. Suggest how the student should proceed. **[1]**

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(g) Explain why the colorimeter is set to zero using a cuvette containing distilled water before any readings are taken. **[1]**

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(h) Calculate the mass of hydrated copper(II) sulfate, $CuSO_4 \cdot 5\,H_2O$, required to prepare $100.0\,cm^3$ of a $0.0500\,mol\,dm^{-3}$ solution of $Cu^{2+}(aq)$. **[2]**

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(i) State **one** advantage of colorimetry over titration for determining the concentration of $Cu^{2+}(aq)$. **[1]**

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**End of examination.**

Total: 35 marks