Chemistry

Standard Level

Paper 1B — Mock Examination

Mock Exam 1

Calculator required

Time allowed: **40 minutes**

Maximum mark: **25 marks**

Candidate information

Candidate name: .....

Session number: .....

Date: .....

Topic emphasis: preparation of a standard solution and volumetric analysis, thermochemical measurement by calorimetry, and gravimetric determination of the water of crystallization of a hydrated salt. 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 **[25 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)	[9 marks]
Question 2	(calorimetry)	[8 marks]
Question 3	(water of crystallization)	[8 marks]
Total		**[25 marks]**

Section B

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

1. A student standardized a solution of sulfuric acid, H_2SO_4, using a standard solution of anhydrous sodium carbonate, Na_2CO_3, prepared in a 250.0 cm^3 volumetric flask.

(a) Calculate the mass, in g, of anhydrous sodium carbonate needed to prepare 250.0 cm^3 of a 0.1000 $mol\,dm^{-3}$ solution. **[1]**

.....

.....

.....

.....

.....

(b) Before filling the burette with the sulfuric acid, the student rinsed it with distilled water only. Explain why this would introduce a systematic error in the calculated concentration of the acid. **[2]**

.....

.....

.....

.....

.....

.....

.....

(This question continues on the following page)

(Question 1 continued)

(c) A 25.00 cm^3 portion of the sodium carbonate solution was titrated with the sulfuric acid. The burette readings are shown below.

Reading	**Titration 1 (rough)**	**Titration 2**	**Titration 3**
Initial burette reading / cm^3	0.00	0.10	0.05
Final burette reading / cm^3	24.60	23.95	23.85
Volume delivered / cm^3			

Complete the table and determine the mean titre that should be used in the calculation, giving a reason for your choice. **[2]**

.....

.....

.....

.....

.....

.....

(d) Determine the concentration, in mol dm^{-3}, of the sulfuric acid, using the equation below.

$$Na_2CO_3(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$$

If you did not determine a mean titre in part (c), use 23.50 cm^3 although this is not the correct answer. **[2]**

.....

.....

.....

.....

.....

.....

(This question continues on the following page)

(Question 1 continued)

(e) Each burette reading has an uncertainty of $\pm 0.05\,\text{cm}^3$. Calculate the percentage uncertainty in the mean titre determined in part (c). **[2]**

.....

.....

.....

.....

.....

.....

.....

2. A student determined the enthalpy change for the reaction between zinc and aqueous copper(II) sulfate.

$$\text{Zn(s)} + \text{CuSO}_4\text{(aq)} \longrightarrow \text{ZnSO}_4\text{(aq)} + \text{Cu(s)}$$

An excess of powdered zinc was added to $50.0\,\text{cm}^3$ of $0.500\,\text{mol}\,\text{dm}^{-3}$ copper(II) sulfate solution in a polystyrene cup. The mixture was stirred and the temperature was recorded.

Data for the reaction of zinc with copper(II) sulfate	
Volume of $\text{CuSO}_4\text{(aq)}$ / cm^3 (± 0.5)	50.0
Concentration of $\text{CuSO}_4\text{(aq)}$ / $\text{mol}\,\text{dm}^{-3}$	0.500
Initial temperature / °C (± 0.1)	21.4
Maximum temperature recorded / °C (± 0.1)	45.2

(This question continues on the following page)

(Question 2 continued)

(a) Determine the energy, in kJ, released by the reaction, using sections 1 and 2 of the data booklet. Assume the solution has the same density and specific heat capacity as water. **[2]**

.....

.....

.....

.....

.....

.....

.....

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

If you did not obtain an answer to part (a), use 5.20 kJ although this is not the correct answer. **[2]**

.....

.....

.....

.....

.....

.....

.....

(This question continues on the following page)

(Question 2 continued)

(c) The literature value for this reaction is $-219\,kJ\,mol^{-1}$. Calculate the percentage error in the student's value. **[1]**

(d) Deduce **two** sources of systematic error in this experiment that are consistent with the direction of the error found in part (c). **[2]**

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

3. Hydrated magnesium sulfate has the formula $MgSO_4 \cdot xH_2O$. A student determined the value of x by heating a sample in a crucible until all of the water of crystallization had been driven off. All masses were measured on a balance with an uncertainty of ± 0.001 g.

Data for the hydrated magnesium sulfate sample	
Mass of empty crucible / g	24.560
Mass of crucible + hydrated salt / g	27.021
Mass of crucible + residue after heating / g	25.762

(a) The crucible and its contents were heated, cooled and reweighed several times. State why this procedure was necessary. **[1]**

.....

.....

.....

.....

.....

(b) Determine the amount, in mol, of anhydrous magnesium sulfate and of water in the sample, and hence deduce the value of x. **[3]**

.....

.....

.....

.....

.....

.....

.....

.....

(This question continues on the following page)

(Question 3 continued)

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

(d) Suggest one experimental error that would give a value of x lower than the true value. **[1]**

(e) Hydrated magnesium sulfate must be stored in a stoppered container. Suggest why storing the solid in an open container would affect the value of x obtained. **[1]**

End of examination.

Total: **25 marks**