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**Chemistry
Higher level
Paper 1B**

16 May 2025

Zone A afternoon | **Zone B** afternoon | **Zone C** afternoon

Candidate session number

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2 hours [Paper 1A and Paper 1B]

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed 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 paper 1B is **[35 marks]**.
- The maximum mark for paper 1A and paper 1B is **[75 marks]**.



Section B

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

1. Nitrogen dioxide, NO_2 , is a brown, toxic and corrosive gas. It can be made in a school laboratory by heating a group II metal nitrate or by the reaction of copper, Cu, with concentrated nitric acid, HNO_3 .

(a) (i) Suggest, with reasons, **two** different safety precautions that should be taken when performing both of these experiments. [2]

Precaution 1:

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Reason:

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Precaution 2:

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Reason:

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(ii) Deduce the coefficients in the equation for the reaction of Cu with concentrated HNO_3 . [1]

___ Cu(s) + ___ $\text{HNO}_3(\text{aq})$ \rightarrow ___ $\text{Cu(NO}_3)_2(\text{aq})$ + ___ $\text{NO}_2(\text{g})$ + ___ $\text{H}_2\text{O(l)}$

(iii) Calculate the mass, in g, of Cu required to make 0.0100 moles of NO_2 . Use section 7 of the data booklet. [1]

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(This question continues on the following page)



(Question 1 continued)

- (b) The NO₂ made was sealed in a glass vessel where the following equilibrium reaction occurred:



Suggest **two** measurements, other than colour change, that could be used to monitor the progress of this reaction over time and the expected results.

[4]

Measurement 1:
Expected result:
.....
Measurement 2:
Expected result:
.....

- (c) A sample of 0.0100 moles of NO₂ was placed in a 1 dm³ sealed container and maintained at a constant temperature of 40°C.

- (i) Suggest how the constant temperature could be easily maintained in a school laboratory.

[1]

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- (ii) The equilibrium concentration of NO₂ was monitored using colorimetry. A student started the experiment and recorded the absorbance value immediately.

Suggest why this may not give a reliable result.

[1]

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(This question continues on the following page)



(Question 1 continued)

- (iii) Suggest how the problem identified in part (c)(ii) could be overcome. [1]

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- (d) The equilibrium was investigated at 0 °C and it was found that 0.00732 moles of NO₂, remained in the container from the original 0.0100 moles.

Determine the value of the equilibrium constant, *K* for this equilibrium at 0 °C. [2]

$$K = \frac{[\text{N}_2\text{O}_4]}{[\text{NO}_2]^2}$$

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- (e) The initial amount of NO₂ was determined by titration. The oxide was first dissolved in water according to the following equation:



The solution was made up to 250.0 cm³ and 25.0 cm³ portions of this solution were then titrated against a 0.0500 mol dm⁻³ standard solution of sodium hydroxide, NaOH.

(This question continues on the following page)



(Question 1 continued)

- (i) Draw a table that can be used for recording the results of the titration experiment described in part (e). Include variables, units and any other relevant information in the header row(s) **and/or** header column(s), **but leave the data cells blank.** [2]

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- (ii) The equipment used for the titration of the analysed mixture with NaOH had an uncertainty of $\pm 0.05 \text{ cm}^3$. The average volume of the titrant was 20.05 cm^3 .
Determine the % uncertainty in this volume. [1]

.....

(This question continues on the following page)



Turn over

(Question 1 continued)

The experiment described in part (b) was repeated three more times at different temperatures. The following values for the equilibrium constant, K , were determined:



T (°C)	T (K)	K
0.0		Value from (d)
20.0		4.74
50.0		5.76×10^{-1}
100.0		3.64×10^{-2}

- (iii) Calculate the values for temperature, T , in degrees kelvin, K , and complete the table. [1]

- (iv) Deduce if the results in part (e)(iii) are consistent with the enthalpy of reaction data given in part (b). [1]

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2. In a separate experiment, the rate of a reaction was studied using colorimetry. During the reaction, the mixture changed colour from orange to green.

Before the investigation could be carried out, it was necessary to construct a calibration curve for the colorimeter.

(a) Describe how a standard aqueous solution can be prepared. [3]

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(b) Describe how this solution can be used to construct a calibration curve. [3]

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(c) Explain how this curve can be used to determine the unknown concentration. [1]

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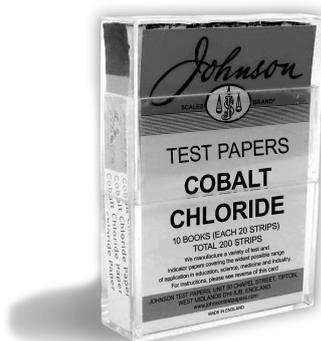
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3. Cobalt(II) chloride has been used for many years as a qualitative test for water, H₂O.



Hydrated cobalt(II) chloride has the formula $\text{CoCl}_2 \cdot \text{X}\text{H}_2\text{O}$ where **X** can be 1, 2, 6 or 9.

A teacher set a task to determine the value of **X**. Hydrated cobalt(II) chloride is pink in colour and anhydrous cobalt(II) chloride is blue.

A group of students weighed 10.000 g of hydrated cobalt(II) chloride and left it overnight in an oven at 30 °C. They observed a slight colour change from the original pink as a result.

(a) (i) Suggest a reason for this.

[1]

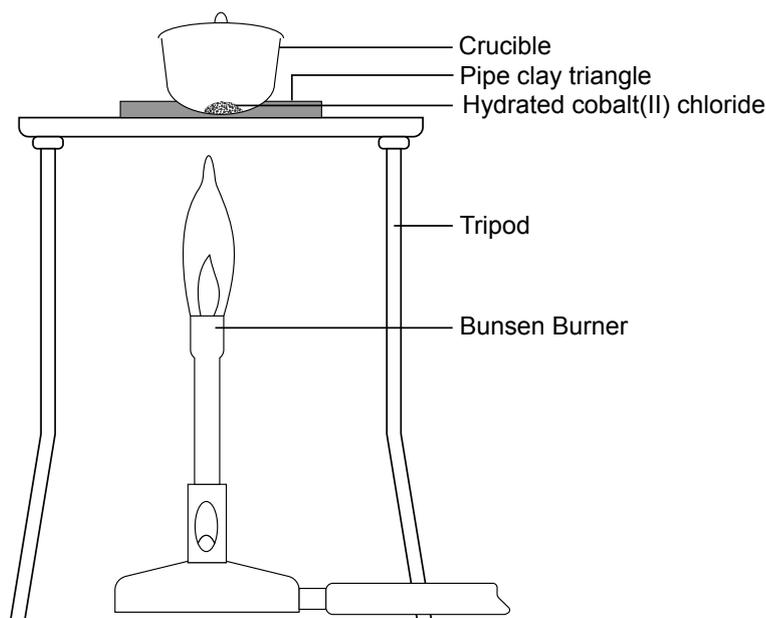
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The students modified their method and heated a known mass of hydrated cobalt(II) chloride using the equipment shown in the following diagram.



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(Question 3 continued)

Each student heated the hydrated cobalt(II) chloride until no further observable change was seen, allowed it to cool and recorded the mass.

The following equation illustrates the process occurring:



- (ii) Suggest how the students could ensure that the dehydration was complete. [1]

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- (iii) Suggest how the students could reduce the impact of systematic error for the values of the mass change. [1]

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- (b) Each of the students carried out the same experiment using different masses of hydrated cobalt(II) chloride. The shared results are shown below.

Experiment number	Mass of $\text{CoCl}_2 \cdot \text{XH}_2\text{O}$	Mass of CoCl_2	Loss in mass (g)	Amount of CoCl_2 /mol	Amount of H_2O /mol
1	4.256	2.299	1.957	0.018	0.109
2	5.711	3.117	2.594	0.024	0.144
3	6.853	4.501	2.352	0.029	0.131
4	8.224	4.470	3.754	0.035	0.208
5	9.868	5.372	4.496	0.041	0.250
6	11.842	6.481		0.050	
7	14.210	7.761	6.449	0.060	0.358
8	17.052	8.222	8.830	0.063	0.490
9	20.463	11.172	9.291	0.086	0.516
10	24.555	13.396	11.159	0.103	0.619

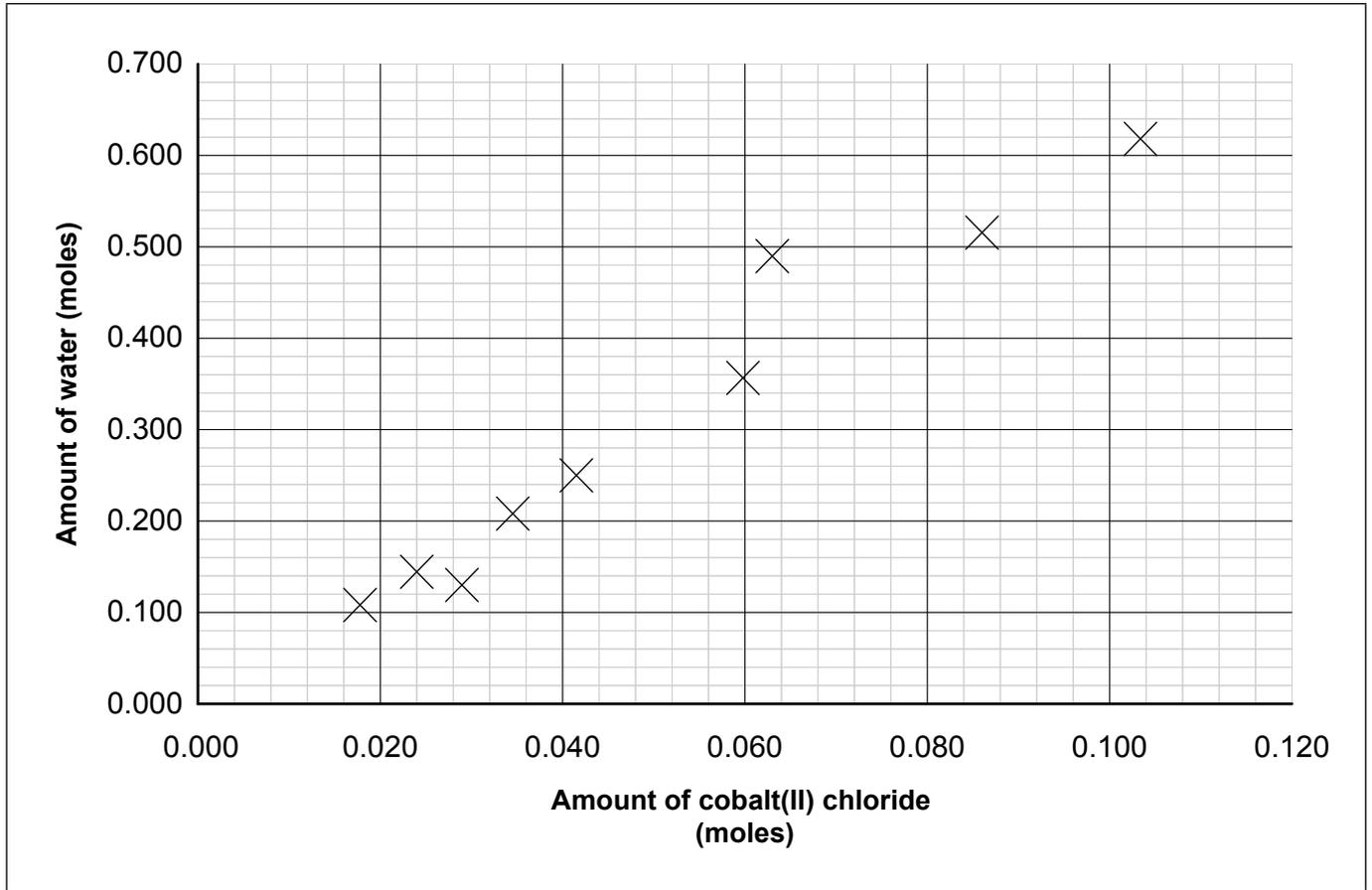
- (i) Determine the missing values in the table above ($M_r \text{H}_2\text{O} = 18.02 \text{g mol}^{-1}$). [1]

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(Question 3 continued)

A graph of the results was plotted.



(ii) Draw a line of best fit on this graph. Extrapolate to the axes. [2]

(iii) Determine the independent and dependent variables in these plotted results. [1]

Independent variable:

Dependent variable:

(This question continues on the following page)



(Question 3 continued)

- (iv) Suggest, with a reason, any result on the graph you consider to be an anomaly.
Circle the point on the graph. [2]

Reason for anomaly:

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- (v) Determine the value of **X**. [1]

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References:

3. With permission from Johnson Analytica Ltd.
3. (a)(ii) With permission from the Royal Society of Chemistry.

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