Chemistry

Higher Level

Paper 1B — Mock Examination

Mock Exam 2

Calculator required

Time allowed: **55 minutes**

Maximum mark: **35 marks**

Candidate information

Candidate name: .....

Session number: .....

Date: .....

Topic emphasis: measurement of reaction rate by gas collection, graphical determination of initial rate, organic synthesis with purification by recrystallization, product identification by melting point and infrared spectroscopy, and the analysis of a pH titration curve. 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 molar volume of an ideal gas at STP to be 22.7 $dm^3\,mol^{-1}$.

Mark allocation

Question 1 (rates of reaction)	[12 marks]
Question 2 (synthesis and purification)	[12 marks]
Question 3 (pH titration curve)	[11 marks]
Total	**[35 marks]**

Section B

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

1. A student investigated the rate of reaction between magnesium ribbon and hydrochloric acid. A 0.0640 g piece of magnesium was added to 25.0 cm^3 of 0.500 $mol\,dm^{-3}$ hydrochloric acid at 298 K, and the volume of hydrogen collected in a gas syringe was recorded.

Time / s ($\pm$1)	0	10	20	30	40	50	60	80	100
Volume of H_2 / cm^3 ($\pm$1)	0	18	32	43	51	56	59	60	60

(a) Deduce the equation for the reaction taking place, including state symbols. **[1]**

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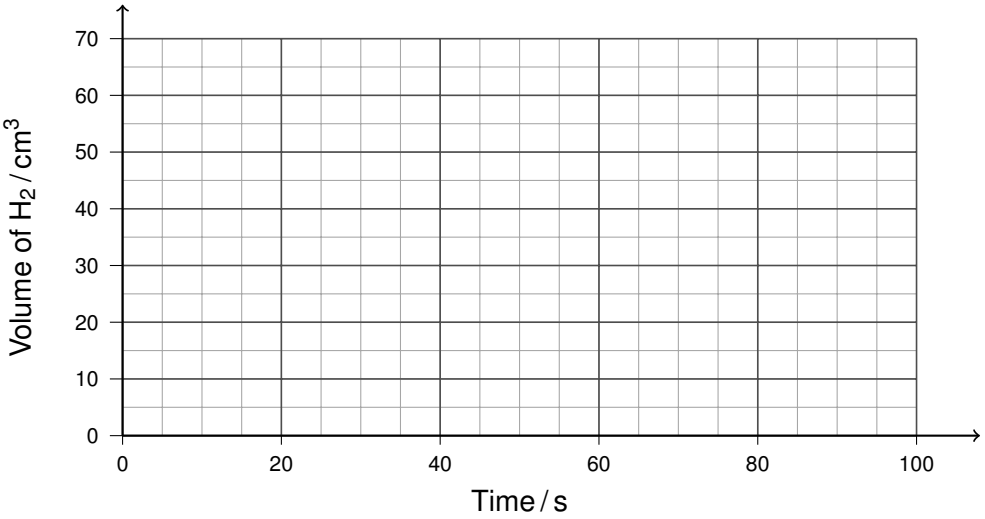
(b) Plot the data on the grid below and draw a smooth best-fit curve. **[2]**



(c) Determine the initial rate of reaction, in $cm^3\,s^{-1}$, by drawing a tangent to your curve at $t = 0$. **[2]**

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(This question continues on the following page)

(Question 1 continued)

(d) Explain, in terms of collision theory, why the gradient of the curve decreases as the reaction proceeds. **[2]**

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(e) Deduce, by calculation, which reactant was the limiting reactant. **[2]**

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(f) The final volume of gas collected was smaller than the theoretical value. Suggest **two** reasons for this. **[2]**

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(g) State how the curve would differ if the experiment were repeated at 308 K, with all other conditions unchanged. **[1]**

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2. Aspirin, $C_9H_8O_4$, is prepared by warming salicylic acid, $C_7H_6O_3$, with an excess of ethanoic anhydride, $C_4H_6O_3$, in the presence of a few drops of concentrated phosphoric acid.

$$C_7H_6O_3 + C_4H_6O_3 \longrightarrow C_9H_8O_4 + CH_3COOH$$

A student used 2.00 g of salicylic acid and obtained 1.62 g of dry, purified aspirin.

(a) Calculate the theoretical yield of aspirin, in g. **[1]**

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(b) Calculate the percentage yield obtained by the student. **[1]**

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(c) The crude product was purified by recrystallization. Describe how this technique is carried out. **[3]**

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(d) The student measured the melting point of the purified product as 128–133 °C. Pure aspirin melts sharply at 135 °C.

Deduce what this observation indicates about the product. **[2]**

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(Question 2 continued)

(e) The infrared spectrum of the product was recorded. State the wavenumber range of **two** absorptions, other than C–H, that would be expected for aspirin, and identify the bond responsible for each, using section 20 of the data booklet. **[2]**

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(f) Calculate the percentage atom economy for the formation of aspirin in this synthesis. **[2]**

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(g) Explain why the product must be dried to constant mass before the yield is calculated. **[1]**

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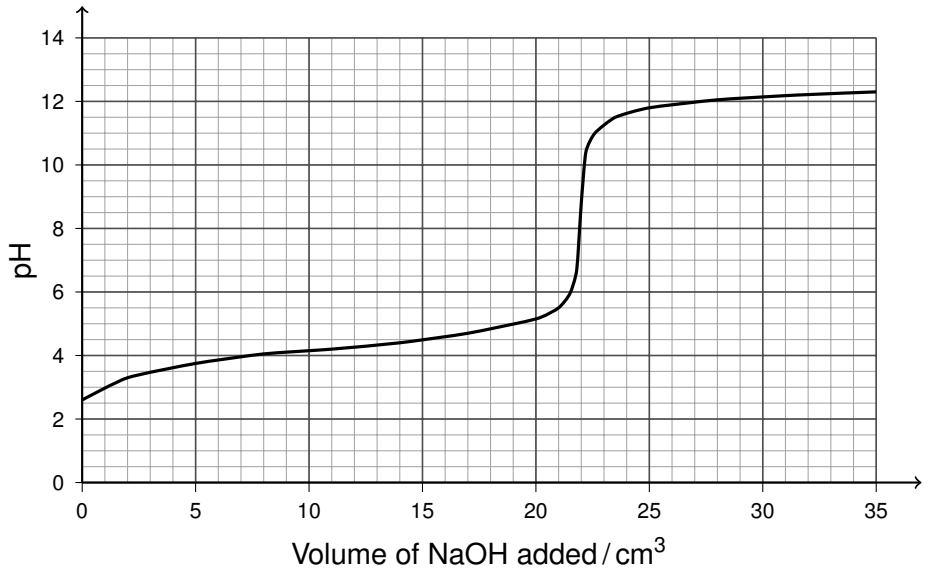
3. A 25.00 cm^3 sample of a weak monoprotic acid, HA, of unknown concentration was titrated with 0.100 $mol\,dm^{-3}$ aqueous sodium hydroxide. The pH was monitored with a calibrated pH probe.



(a) Determine the volume of sodium hydroxide required to reach the equivalence point. **[1]**

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(b) Determine the concentration of the acid HA. **[2]**

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(c) Determine the pK_a of HA from the graph, explaining how you obtained the value. **[2]**

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(Question 3 continued)

(d) Explain why the pH changes only slowly between 5 cm^3 and 18 cm^3 of added sodium hydroxide. **[2]**

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(e) Explain why the pH at the equivalence point is greater than 7. **[2]**

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(f) State the name of a suitable indicator for this titration, using section 18 of the data booklet, and state **one** advantage of using a pH probe instead of an indicator. **[2]**

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End of examination.

Total: 35 marks