Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **February/March 2024**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.

This document has **12** pages. Any blank pages are indicated.

[Turn over

1 Sea water contains about 20 g dm^{-3} of chloride ions, $Cl^-(aq)$.

The exact concentration of $Cl^-(aq)$ in sea water can be determined by titration with aqueous silver ions, $Ag^+(aq)$, using aqueous potassium chromate(VI), $K_2CrO_4(aq)$, as an indicator.

When aqueous silver nitrate, $AgNO_3(aq)$, is added to a sample of sea water, silver ions react with chloride ions to form a precipitate of silver chloride.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

When all of the $Cl^-(aq)$ has reacted with $Ag^+(aq)$, the presence of unreacted $Ag^+(aq)$ is detected by chromate(VI) ions, $CrO_4^{2-}(aq)$. A red precipitate of $Ag_2CrO_4(s)$ is seen.

$$2Ag^+(aq) + CrO_4^{2-}(aq) \rightarrow Ag_2CrO_4(s)$$

The amount of $Ag^+(aq)$ reacting with $Cl^-(aq)$ in the sample of sea water can be calculated in order to determine the concentration of $Cl^-(aq)$ in the sample of sea water.

A student uses the following method.

step 1 Use a weighing boat to weigh by difference approximately 10.6 g of $AgNO_3(s)$ into a 100 cm^3 glass beaker.

step 2 Use the sample of $AgNO_3(s)$ in the glass beaker to prepare 250.0 cm^3 of $AgNO_3(aq)$.

step 3 Transfer this solution into a dark brown glass bottle. Label this solution **X**.

step 4 Collect a sample of sea water and remove any solid material present.

step 5 Transfer 10.00 cm^3 of the sea water into a conical flask.

step 6 Add 1 cm^3 of $K_2CrO_4(aq)$ to the conical flask.

step 7 Rinse a burette in preparation for the titration.

step 8 Fill the burette with solution **X**.

step 9 Slowly add solution **X** to the conical flask until the white precipitate turns red. This is the end-point.

(a) Describe how the student should carry out step 1. Include a table in your answer to show how this process is recorded.

.....

.....

[2]

(b) Describe how the student should prepare 250.0 cm^3 of $AgNO_3(aq)$ in step 2, starting with the $AgNO_3(s)$ in the 100 cm^3 beaker in step 1.

.....

.....

.....

.....

..... [3]

(c) Suggest why solution **X** is kept in a dark brown glass bottle in step 3 rather than a colourless glass bottle.

..... [1]

(d) Suggest how solid material should be removed from sea water in step 4.

..... [1]

(e) Identify the most appropriate piece of equipment that you would use to:

(i) transfer 10.00 cm^3 of sea water from the dark brown bottle to a conical flask in step 5

..... [1]

(ii) add 1 cm^3 of $K_2CrO_4(aq)$ to the conical flask in step 6.

..... [1]

(f) Chromate(VI) solutions are known to be carcinogenic. State what precaution should be taken when using $K_2CrO_4(aq)$ in step 6 other than wearing safety goggles.

..... [1]

(g) State what the burette should be rinsed with in step 7.

..... [1]

(h) The student obtains the results shown in Table 1.1.

Table 1.1

	rough titration	titration 1	titration 2	titration 3
final volume / cm^3	23.40	45.75	22.60	45.05
initial volume / cm^3	0.00	23.40	0.00	22.60
titre / cm^3				

(i) Complete Table 1.1. [1]

(ii) Calculate the mean titre to be used in the calculations. Show your working.

mean titre = ... cm^3 [1]

(iii) Use the mean titre from **(h)(ii)** to calculate the concentration of chloride ions in the sample of sea water.
Assume the mass of solid silver nitrate used in step 2 was 10.62 g.

concentration = ... $mol\ dm^{-3}$ [3]

(iv) Calculate the percentage error in the titre in titration 2.
Show your working.

percentage error = ... % [1]

(i) Spectroscopic analysis of the sample of sea water accurately determined the concentration of $Cl^-(aq)$ to be lower than that determined by titration with $Ag^+(aq)$.

Suggest why the student's method gave a higher value.

.....

..... [1]

[Total: 18]

2 A student wants to investigate the rate of the hydrolysis of methyl methanoate, $HCOOCH_3$.

$$HCOOCH_3 + H_2O \rightleftharpoons HCOOH + CH_3OH$$

The reaction is catalysed by dilute hydrochloric acid, HC*l*(aq).

The amount of methanoic acid, HCOOH, produced as the reaction progresses can be monitored by titration with aqueous sodium hydroxide, NaOH(aq), of known concentration using thymolphthalein as the indicator.

To determine this, the volume of NaOH(aq) needed to neutralise the H^+(aq) from the catalyst needs to be found beforehand.

The student uses the following procedure.

step 1 Add approximately 150 cm^3 of iced water to a 250 cm^3 conical flask, **A**.

step 2 Add 200 cm^3 of 0.250 mol dm^{-3} HC*l*(aq) to a 500 cm^3 conical flask, **B**.

Conical flask **B** is the flask in which the reaction takes place.

step 3 Transfer 2.00 cm^3 of 0.250 mol dm^{-3} HC*l*(aq) from conical flask **B** to conical flask **A**. Carry out a single titration of the contents of conical flask **A** with NaOH(aq) of known concentration.

step 4 Add 10.0 cm^3 of methyl methanoate to conical flask **B**, swirl the reaction mixture and immediately start a stopwatch.

step 5 After 1 minute transfer 2.00 cm^3 of the reaction mixture from conical flask **B** into conical flask **A**. Carry out a further single titration of the contents of conical flask **A** against NaOH(aq). Do **not** empty the contents of conical flask **A** between titrations.

step 6 After 10 minutes transfer 2.00 cm^3 of the reaction mixture from conical flask **B** into conical flask **A**. Titrate the contents of conical flask **A** against NaOH(aq).

step 7 Repeat step 6 at intervals of 10 minutes for 1 hour.

(a) State which step is used to determine the concentration of H^+(aq) ions from the catalyst in the mixture.

.....[1]

(b) The iced water in conical flask **A** is used to significantly reduce the rate of reaction.

Suggest **two** reasons why the rate of reaction is significantly reduced when the reaction mixture is transferred to conical flask **A**.

reason 1 .....

.....

reason 2 .....

.....

[2]

(c) Table 2.1 shows the readings taken by the student.

The titrations in steps 4–7 show the volume of NaOH(aq) needed to neutralise both the $H^+(aq)$ ions from the catalyst, HC*l*(aq), and from the HCOOH produced in the reaction.

volume of NaOH(aq) needed, in cm^3, to neutralise $H^+(aq)$ from catalyst = 11.40 cm^3

volume of NaOH(aq), in cm^3, used to neutralise $H^+(aq)$ from HCOOH at time, $t = V_t$

volume of NaOH(aq), in cm^3, used to neutralise $H^+(aq)$ from HCOOH at 60 min = V_∞

Table 2.1

reading	time, t /min	total volume of NaOH(aq) needed to neutralise total amount of $H^+(aq)$ /cm^3	V_t /cm^3	$(V_\infty - V_t)$ /cm^3
1	1	12.60		
2	13	17.70		
3	20	19.90		
4	30	22.10		
5	40			
6	50	24.90		
7	60	25.90		

The student forgot to take reading 5.

(i) Complete Table 2.1. [2]

(ii) Identify the independent variable.

.....

[1]

(iii) Identify **one** variable that needs to be controlled, apart from concentrations and volumes of solutions.

.....

[1]

(iv) Reading 2 should have been taken at 10 minutes and **not** at 13 minutes.

State whether this result should have been included or not. Explain your answer.

.....

.....

[1]

(v) Plot a graph on the grid in Fig. 2.1 to show the relationship between $(V_\infty - V_t)$ and time.

Use a cross (×) to plot each data point. Draw a line of best fit.

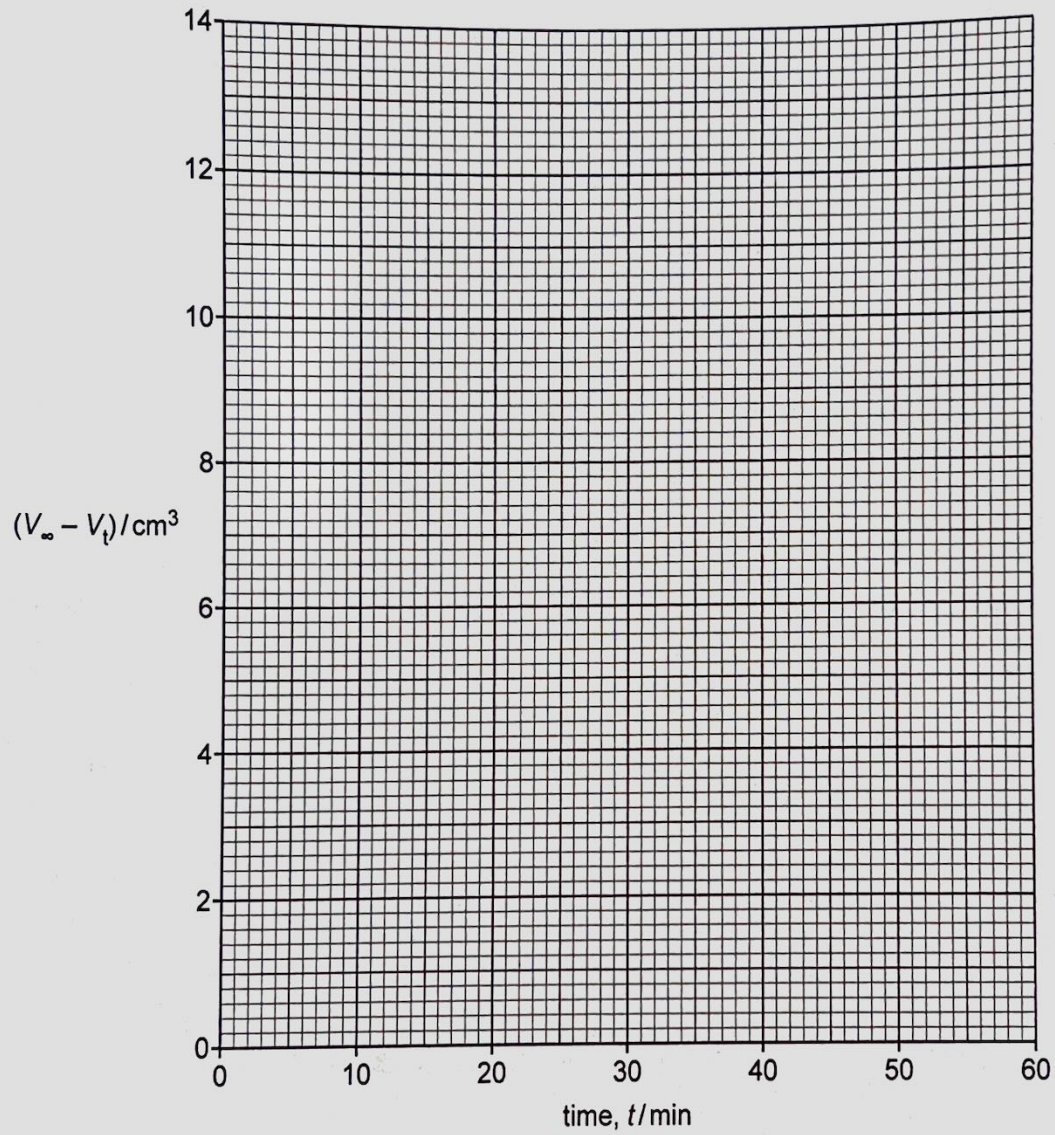

Fig. 2.1

[2]

(vi) Reading 5 was **not** taken. Use the graph to predict the total volume of NaOH(aq) needed to neutralise the total amount of H^+(aq) at 40 minutes.

volume of NaOH(aq) = ... [1]

(vii) It is **not** possible to repeat the experiment.

State whether the data from the experiment is reliable. Justify your answer.

.....

..... [1]

[Total: 12]