Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7050795070

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **October/November 2020**

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, use appropriate units and use an appropriate number of significant figures.

INFORMATION
- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **12** pages. Blank pages are indicated.

1 Aqueous potassium manganate(VII) can be used to determine the amount of iron present in a sample of iron wire by redox titration. Before potassium manganate(VII) can be used, its concentration must be determined using aqueous sodium ethanedioate made from the hydrated solid $Na_2C_2O_4•2H_2O$.

(a) **(i)** Calculate the mass of $Na_2C_2O_4•2H_2O$ required to make $250.0\,cm^3$ of $0.200\,mol\,dm^{-3}$ sodium ethanedioate standard solution.
[A_r: Na, 23.0; C, 12.0; O, 16.0; H, 1.0]

mass of $Na_2C_2O_4•2H_2O$ = ... g [1]

(ii) Describe how the student should accurately prepare $250.0\,cm^3$ of $0.200\,mol\,dm^{-3}$ sodium ethanedioate standard solution from the weighed sample of $Na_2C_2O_4•2H_2O$ of mass calculated in **(a)(i)**.
In your description you should include the names and capacities of any apparatus used.

....

....

....

.... [2]

(b) Ethanedioate ions, $C_2O_4^{2-}$(aq), react with manganate(VII) ions, MnO_4^-(aq), according to the ionic equation shown.

$$2MnO_4^-(aq) + 16H^+(aq) + 5C_2O_4^{2-}(aq) \rightarrow 2Mn^{2+}(aq) + 8H_2O(l) + 10CO_2(g)$$

$25.0\,cm^3$ of $0.200\,mol\,dm^{-3}$ $C_2O_4^{2-}$(aq) required $18.40\,cm^3$ MnO_4^-(aq) for complete reaction.

Calculate the concentration of the aqueous potassium manganate(VII). Give your answer to **three significant figures**.

concentration of aqueous potassium manganate(VII) = ... $mol\,dm^{-3}$ [3]

(c) In another experiment, a student uses 0.0200 mol dm^{-3} $MnO_4^-(aq)$ to analyse the percentage of iron in a sample of iron wire using the following method.

step 1 The mass of the iron wire is recorded.

step 2 The iron wire is dissolved in 20 cm^3, an excess, of sulfuric acid and made up to a volume of 250.0 cm^3 with distilled water. The iron reacts and dissolves in sulfuric acid to form $Fe^{2+}(aq)$ ions.

step 3 A 25.0 cm^3 sample of this Fe^{2+} containing solution is titrated with 0.0200 mol dm^{-3} $MnO_4^-(aq)$.

The ionic equation for the reaction between $MnO_4^-(aq)$ and $Fe^{2+}(aq)$ is shown.

$$MnO_4^-(aq) + 8H^+(aq) + 5Fe^{2+}(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

The student's results are shown in the table.

[A_r: Fe, 55.8]

	rough	titration 1	titration 2	titration 3	titration 4
final burette reading / cm^3	45.50	44.75	44.45	44.80	44.40
initial burette reading / cm^3	0.00	0.10	0.15	0.00	0.00
titre / cm^3	45.50	44.65	44.30	44.80	44.40

(i) Circle the titres the student should use to obtain the most accurate value for the volume of 0.0200 mol dm^{-3} $KMnO_4$ that is needed to react with 25.0 cm^3 of the prepared iron solution. Explain your answer.

....

.... [1]

(ii) The burette used for the titration has graduations every 0.10 cm^3.

Calculate the maximum percentage error in the titre of titration 2.

Show your working.

percentage error = ... [1]

(iii) Derive an expression to show how you would calculate the percentage by mass of iron in the iron wire.
Use x to represent the average titre and y to represent the mass of iron wire used.

expression for mass of iron in the iron wire = ... [2]

(iv) The student left the solution of $Fe^{2+}(aq)$ in sulfuric acid without a stopper for a few days. The student repeated the titration and found that the average titre was lower.

Suggest why.

....

.... [1]

(v) In **step 2**, the sulfuric acid is used to dissolve the iron in the iron wire.

Suggest the other function of the sulfuric acid in this experiment.

....

.... [1]

(d) Name an appropriate piece of apparatus to measure the volume of sulfuric acid in **step 2**. Give a reason for your answer.

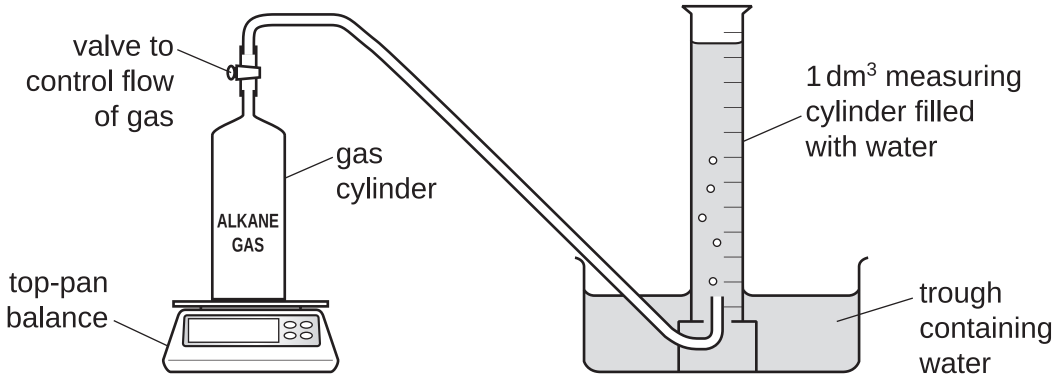
....

.... [1]

[Total: 13]

Question 2 starts on the next page.

2 A student uses the apparatus shown to calculate the relative molecular mass, M_r, of a gaseous alkane. The experiment took place at 298 K and 101 kPa.



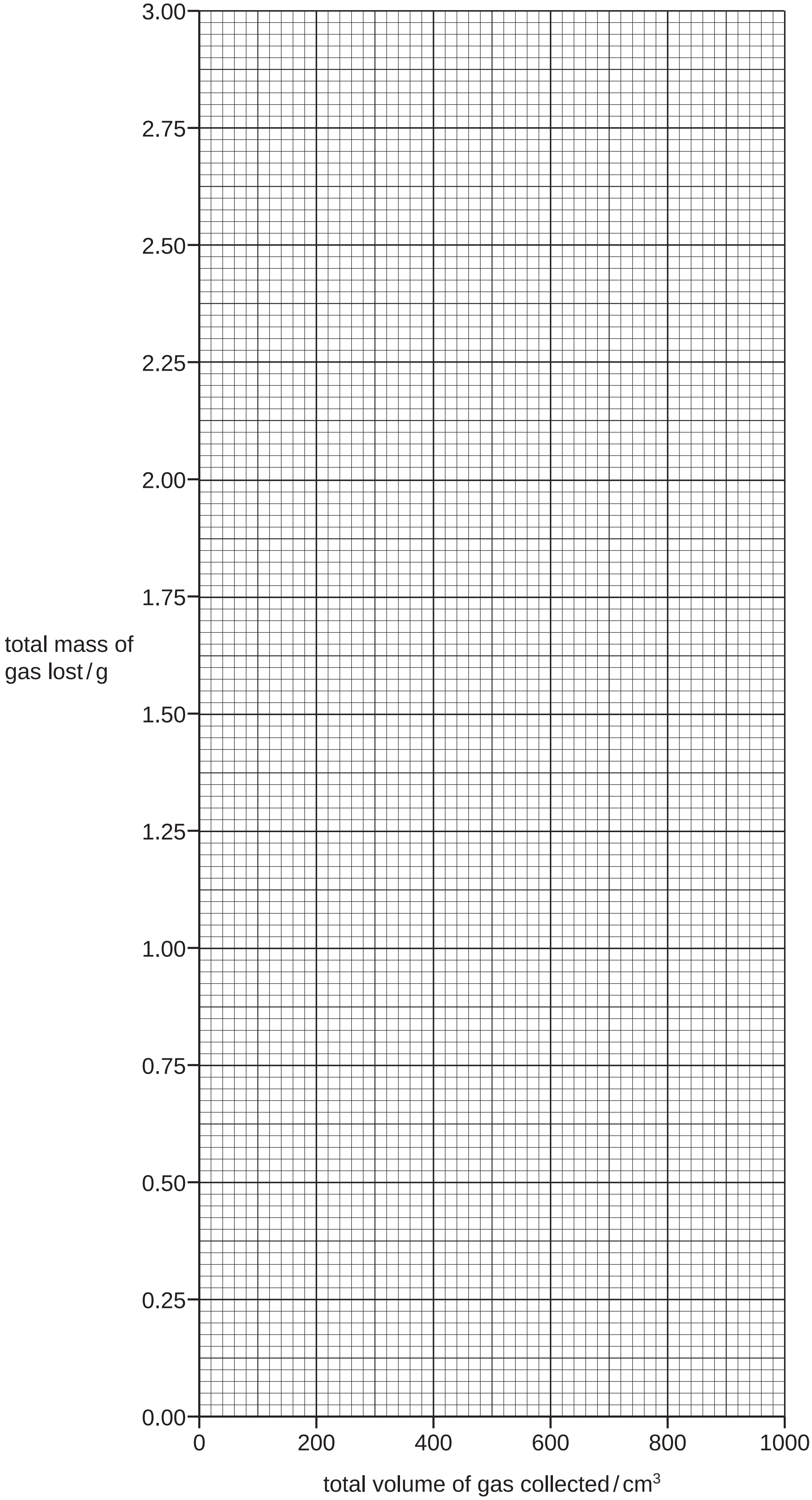
The alkane is flammable.

The student opens the tap and allows a small amount of the alkane gas into the measuring cylinder, displacing water. The gas in the measuring cylinder is allowed to reach room temperature and the volume recorded. This process is repeated and the measurements of mass of gas cylinder and total volume of gas collected are recorded in the table.

A	B	C
mass of gas cylinder / g	total volume of gas collected / cm^3	total mass of gas lost from the cylinder / g
164.02	0	0.00
163.77	100	
163.65	150	
163.48	230	
163.26	320	
163.02	420	
162.72	550	
162.38	720	
162.11	800	
161.83	930	

(a) Complete column C in the table. The first reading has been done for you. Give all values to **two decimal places**. [1]

(b) (i) Plot a graph on the grid of total mass of gas lost against the total volume of gas collected. Use a cross (×) to plot each data point. Draw a line of best fit.


3.00
2.75
2.50
2.25
2.00
1.75
total mass of gas lost / g
1.50
1.25
1.00
0.75
0.50
0.25
0.00
0
200
400
600
800
1000
total volume of gas collected / cm3

[2]

(ii) Circle the point which you think is most anomalous on your graph. [1]

(iii) Suggest **one** reason that explains the anomalous result you have circled.

....

.... [1]

(c) (i) Use the graph to determine the gradient of the line of best fit.

State the coordinates of both points you used in your calculation. These must be selected from your line of best fit.

Give the gradient to **three significant figures**.

coordinates 1 .... coordinates 2 ....

gradient = ... $g\,cm^{-3}$
[2]

(ii) The ideal gas equation states that $pV = nRT$, where $R = 8.31\,J\,mol^{-1}\,K^{-1}$.

Use the ideal gas equation and your answer to **(c)(i)** to calculate an experimental value for the M_r of the alkane gas.
Give your answer to **one decimal place**. Show your working.

M_r = ... [2]

(iii) Suggest the identity of the alkane gas. Explain your suggestion.

....

.... [1]

(d) **(i)** Suggest **two** ways in which the accuracy of the measurements may be improved.

....

....

.... [2]

(ii) Apart from wearing eye protection or a lab coat, state **one** safety precaution which the student must take when carrying out this experiment.

.... [1]

(iii) The student is told that samples of the alkane gas are sometimes contaminated with a more volatile alkane.

State and explain how this would affect the gradient of the graph.

....

....

.... [2]

(iv) In each experiment the gas was allowed to reach the temperature of the room (298 K) before the volume was measured.

Explain why this was necessary for the calculation of the M_r of the alkane.

....

.... [1]

(v) Suggest how the reliability of the experiment could be improved.

.... [1]

[Total: 17]

BLANK PAGE

BLANK PAGE

BLANK PAGE