Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2015**

1 hour 15 minutes

Candidates answer on the Question Paper.

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **9** printed pages and **3** blank pages.

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1 A saturated aqueous solution of magnesium methanoate, $Mg(HCOO)_2$, has a solubility of approximately 150 g dm^{-3} at room temperature. Its exact solubility can be determined by titrating magnesium methanoate against aqueous potassium manganate(VII).

During the titration, the methanoate ion, $HCOO^-$, is oxidised to carbon dioxide while the manganate(VII) ion, MnO_4^-, is reduced to Mn^{2+}.

You are supplied with:
a saturated aqueous solution of $Mg(HCOO)_2$
aqueous potassium manganate(VII), $KMnO_4$, of concentration 0.0200 mol dm^{-3}

(a) (i) Write the half equations for the oxidation of $HCOO^-(aq)$ to $CO_2(g)$ and the reduction of $MnO_4^-(aq)$ to $Mn^{2+}(aq)$ in acid solution.

.....

..... [2]

(ii) Using the approximate solubility above, calculate the concentration, in mol dm^{-3}, of the saturated aqueous magnesium methanoate and the concentration of the methanoate ions present in this solution.
[A_r: H, 1.0; C, 12.0; O, 16.0; Mg, 24.3]

[2]

(iii) In order to obtain a reliable titre value, the saturated solution of magnesium methanoate needs to be diluted.

Describe how you would accurately measure a 5.0 cm^3 sample of saturated magnesium methanoate solution and use it to prepare a solution fifty times more dilute than the saturated solution.

.....

.....

.....

..... [2]

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(iv) Before the titration is carried out, dilute sulfuric acid must be added to the magnesium methanoate.

Explain why this is necessary and also whether the volume of sulfuric acid chosen will affect the result of the titration.

.....

.....

.....

..... [2]

(v) The potassium manganate(VII) is added from a burette into the magnesium methanoate in a conical flask.

Describe what you would see when you had reached the end-point of the titration.

.....

..... [1]

(vi) 1 mol of acidified MnO_4^- ions reacts with 2.5 mol of $HCOO^-$ ions.

25.0 cm^3 of the diluted solution prepared in **(iii)** required 25.50 cm^3 of 0.0200 mol dm^{-3} potassium manganate(VII) solution to reach the end-point.

Use this information to calculate the concentration, in mol dm^{-3}, of $HCOO^-$ ions in the diluted solution.

..... mol dm^{-3} [1]

(vii) Use your answer to **(vi)** to calculate the concentration, in mol dm^{-3}, of the saturated solution of magnesium methanoate, $Mg(HCOO)_2$. Give your answer to **three significant figures**.

..... mol dm^{-3} [1]

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(b) The solubility of magnesium methanoate can be determined at higher temperatures using the same titration.

In an experiment to determine how the concentration of saturated magnesium methanoate varies with temperature, name the independent variable and the dependent variable.

independent variable .....

dependent variable .....
[1]

(c) The solubility of magnesium methanoate increases with temperature.

What does this tell you about ΔH for the process below?

$$Mg(HCOO)_2(s) \rightleftharpoons Mg^{2+}(aq) + 2HCOO^-(aq)$$

Explain your answer.

.....

.....

.....

..... [2]

(d) A student used the same titration method, this time to measure the concentration of a saturated solution of *barium* methanoate.

Explain why the acidification of the solution with dilute sulfuric acid might make the titration difficult to do.

.....

..... [1]

[Total: 15]

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QUESTION 2 STARTS ON THE NEXT PAGE.

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2 At high temperatures a mixture of iodine and hydrogen gases reacts to form an equilibrium with gaseous hydrogen iodide.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g)$$

(a) (i) Write an expression for the equilibrium constant, K_c, based on concentration, for this reaction.

[1]

(ii) If the starting concentration of both iodine and hydrogen was **a** mol dm^{-3} and it was found that 2**y** mol dm^{-3} of hydrogen iodide had formed once equilibrium had been established, write K_c in terms of **a** and **y**.

[1]

(b) The expression for the equilibrium constant from **(a)(ii)** can be re-written as shown below.

$$\mathbf{y} = \frac{\mathbf{a}\sqrt{K_c}}{2 + \sqrt{K_c}}$$

In an experiment, air was removed from a 1 dm^3 flask and amounts of hydrogen and iodine gases were mixed together such that their initial concentrations were both **a** mol dm^{-3}. This mixture was allowed to come to equilibrium at 760 K in the flask. The equilibrium concentration of iodine, (**a** – **y**) mol dm^{-3}, was then measured.

The experiment was repeated for various initial concentrations, **a** mol dm^{-3}, and the results were recorded in the table below.

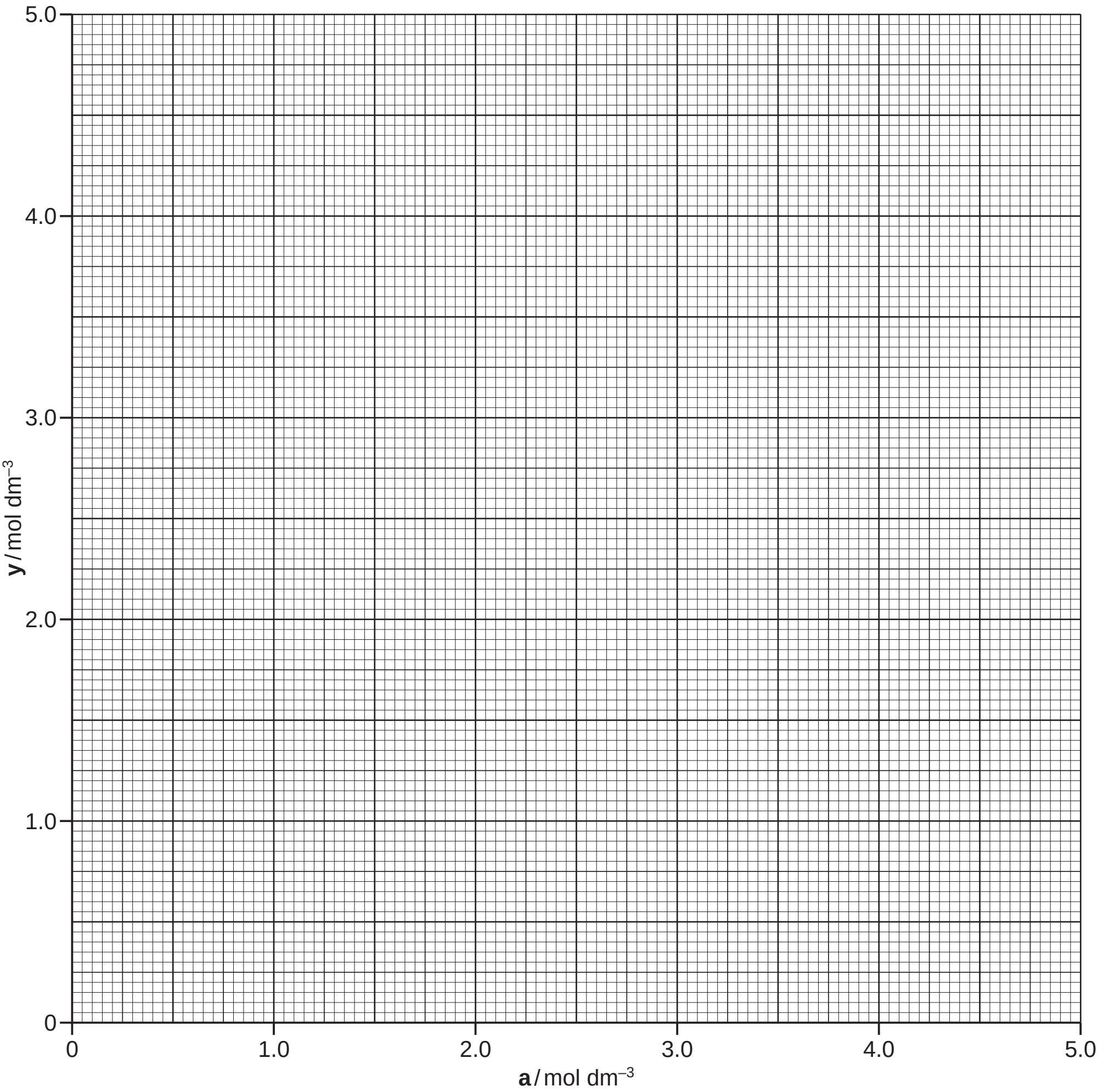
(i) Complete the table to give the values of **y** mol dm^{-3} to **three decimal places**.

a mol dm^{-3}	(**a** – **y**) mol dm^{-3}	**y** mol dm^{-3}
0.200	0.022	0.178
0.500	0.050	
0.800	0.252	
1.000	0.200	
1.500	0.365	
2.100	0.570	
2.800	0.652	
3.400	0.700	
3.800	0.867	
4.200	0.868	
4.900	1.150	

[2]

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(ii) Plot a graph to show how **y** mol dm^{-3} varies with initial concentrations of hydrogen and iodine, **a** mol dm^{-3}.



[1]

(iii) Use your points to draw a line of best fit. [1]

(c) **(i)** Determine the slope of your graph. State the co-ordinates of both points you used for your calculation. Record the value of the slope to **three significant figures**.

co-ordinates of both points used ....

slope = ...
[2]

(ii) Use the value of your slope and the equation in **(b)** to calculate the value of K_c. Your working **must** be shown.

[2]

(d) Explain why, for safety reasons, it is necessary to remove air from the 1 dm^3 flask.

.....

..... [1]

(e) One of the experiments in **(b)** was repeated in a 500 cm^3 flask instead of the 1 dm^3 flask.

What effect, if any, would this have on the rate of reaction and the value of K_c measured?

.....

.....

.....

.....

..... [2]

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(f) The reaction of hydrogen and iodine to form hydrogen iodide is exothermic.

$$H_2(g) + I_2(g) \rightleftharpoons 2HI(g) \qquad \Delta H = -9.6\,kJ\,mol^{-1}$$

(i) On your graph, draw and label the line you would expect if the experiment was performed at 1000 K instead of 760 K. [1]

(ii) What effect, if any, would the higher temperature have on the value of K_c?

.....

..... [1]

[Total: 15]

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