GradeMax

Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0322410782

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2017**

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 **11** printed pages and **1** blank page.

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1 The pain of muscle strains and swellings can be eased by using heat packs. As a source of heat, some heat packs use the energy released when anhydrous calcium chloride dissolves in water.

$$CaCl_2(s) \xrightarrow{\text{water}} Ca^{2+}(aq) + 2Cl^-(aq)$$

A heat pack consists of a bag of water, inside which a smaller bag contains anhydrous calcium chloride. When pressure is applied to the heat pack, the smaller bag bursts releasing the anhydrous calcium chloride into the water. The heat pack is shaken to speed up dissolving. Energy is released which warms the heat pack.

A student carried out an experiment to determine the enthalpy change when anhydrous calcium chloride dissolves in distilled water. The results the student obtained are plotted on the graph on page 4.

(a) By considering the graph of results, draw a labelled diagram of the experimental set-up that the student could have used to produce the graph shown.
Label the apparatus and chemicals required to measure the **two** variables.

[2]

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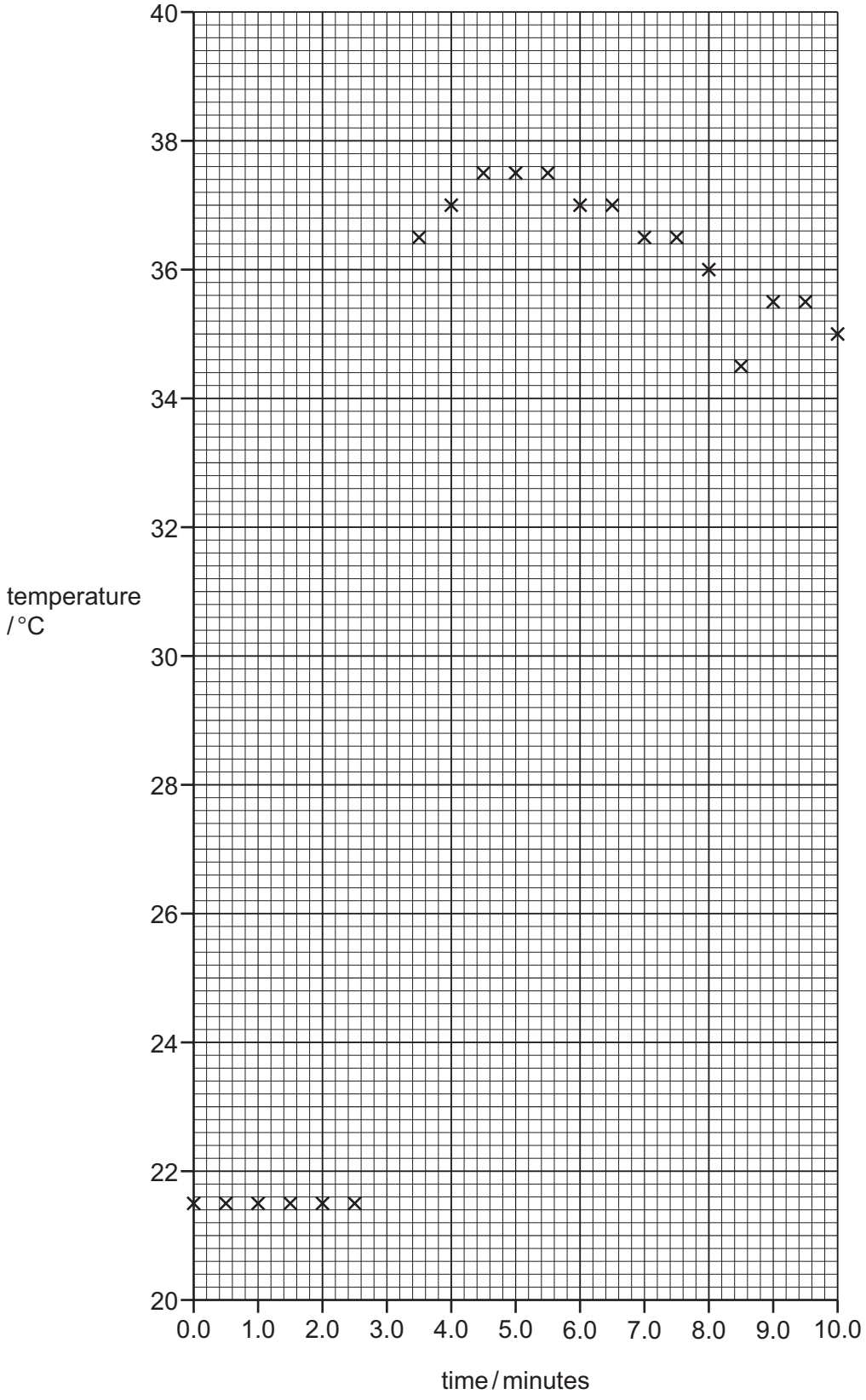
[Turn over

4


40
38
36
34
32
30
28
26
24
22
20
temperature / °C
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
time / minutes

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(b) Explain why the student took readings between 0.0 minutes and 2.5 minutes.

.....

..... [1]

(c) Explain why the student did not take a reading at 3.0 minutes.

.....

..... [1]

(d) Explain why the temperature continued to increase between 3.5 minutes and 4.5 minutes.

.....

..... [1]

(e) Draw two straight lines of best fit on the grid. Extrapolate these lines to estimate the theoretical temperature rise at 3.0 minutes. Give your answer to **one** decimal place.

theoretical temperature rise at 3.0 minutes = ... °C [2]

(f) One of the results is anomalous. This occurred because the student took the thermometer out of the solution and then replaced it just before the reading was taken.

The time at which the anomalous reading was taken was ..... minutes.

Explain why these actions led to the anomalous point.

.....

..... [1]

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(g) Explain why stirring the mixture would make this experiment more reliable.

.....

.....

..... [1]

(h) Anhydrous calcium chloride is classified as a moderate health hazard. It is an irritant.

Apart from wearing eye protection, state **one** other relevant safety precaution the student should have taken.

.....

..... [1]

(i) The student found the value for the enthalpy change of solution of anhydrous calcium chloride to be –82.5 kJ mol^{-1}.
A manufacturer produces a heat pack that contains 75.0 g of water.

Calculate the mass of anhydrous calcium chloride the manufacturer must use in the inner bag to produce a rise in temperature of 30.0 °C.
The specific heat capacity of water, c = 4.18 J g^{-1} K^{-1}.
[A_r: Ca, 40.1; Cl, 35.5]

mass of anhydrous CaCl_2 = ... g [2]

[Total: 12]

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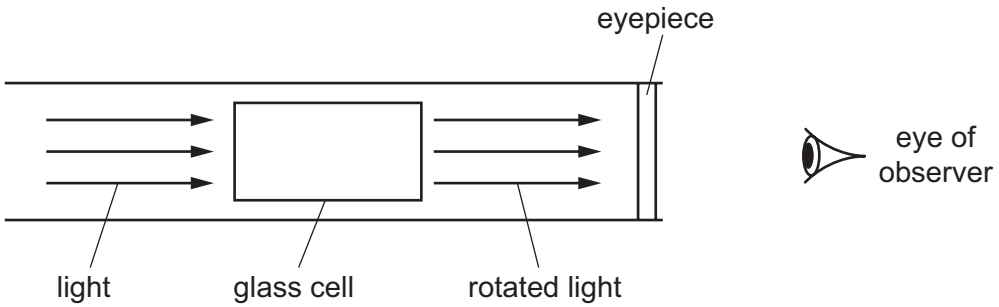
2 Sucrose is a sugar. The concentration of a solution of sucrose can be measured by the optical rotation, α, of a sucrose solution. The more concentrated the solution, the greater the optical rotation of the solution.

A polarimeter is used to measure optical rotation. Light is passed through a sample of the sucrose solution in a glass cell, and the observed angle of rotation, α_{obs}, is measured.

A simplified diagram of a polarimeter is shown.



If a glass cell of length 10 cm is filled with a solution of sucrose of concentration 1 g cm^{-3} the measured angle of rotation is known as the specific rotation, [α].

The observed angle of rotation, α_{obs}, measured by the polarimeter is related mathematically to the concentration of the sucrose solution by the equation shown.

$$\alpha_{obs} = [\alpha]c$$

α_{obs} is the observed angle of rotation using a 10 cm cell

[α] is the specific rotation of sucrose solution

c is the concentration of sucrose, in g cm^{-3}

A student wanted to determine the specific rotation of sucrose, [α]. Solutions of different concentrations of sucrose at 20 °C were placed in a polarimeter and the observed angle of rotation, α_{obs}, recorded. The '+' sign is used to show that the rotation is in a clockwise direction.

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[Turn over

concentration of sucrose, c / g cm^{-3}	observed angle of rotation, α_{obs}
0.0750	+5.05
0.0700	+4.70
0.0650	+4.40
0.0600	+4.00
0.0500	+3.30
0.0450	+2.55
0.0350	+2.30
0.0300	+1.95
0.0250	+1.68
0.0200	+1.40

(a) (i) Plot a graph on the grid on page 9 to show the relationship between concentration of sucrose, c, and observed angle of rotation, α_{obs}.
Use a cross (×) to plot each data point. Draw a line of best fit. [2]

(ii) Circle the most anomalous point on your graph. [1]

(iii) Use the graph to determine the specific rotation, [α], of sucrose.
Give this value to **two decimal places**.
State the co-ordinates of both points you used in your calculation.

co-ordinates 1 ..... co-ordinates 2 .....

specific rotation of sucrose, [α] = ...
[2]

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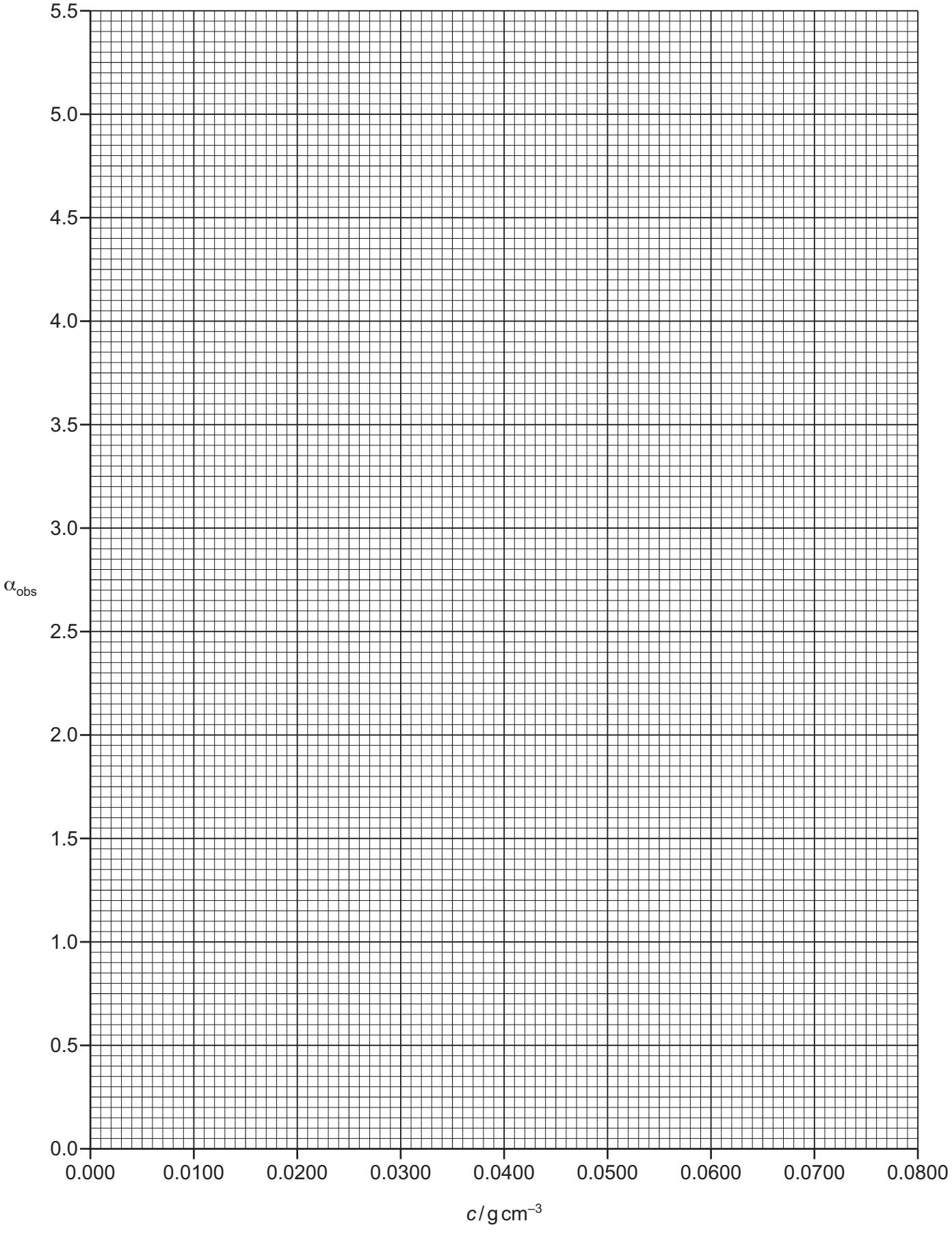
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
α_{obs}
0.000
0.0100
0.0200
0.0300
0.0400
0.0500
0.0600
0.0700
0.0800
c / g cm^{-3}

(b) You are asked to write instructions for another student to follow so they can prepare a standard solution of 250 cm^3 0.0750 g cm^{-3} sucrose. The student is provided with solid sucrose and a 250 cm^3 volumetric flask.

(i) Calculate the mass, in g, of sucrose the student would need to use.

mass of sucrose = ... g [1]

(ii) Describe how the student should accurately prepare the standard solution using a sample of sucrose of mass calculated in **(i)**.

.....

.....

.....

.....

.....

..... [2]

(c) (i) The student used the standard solution prepared in **(b)** to prepare the solutions in the table on page 8.

Calculate the volume of standard solution of concentration 0.0750 g cm^{-3} and the volume of distilled water needed to prepare 15.00 cm^3 of sucrose solution of concentration 0.0350 g cm^{-3}.
Give your answers to **two** decimal places.

volume of standard solution = ... cm^3

volume of distilled water = ... cm^3
[1]

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The volumes of the two solutions given in **(c)(i)** could be measured using the same type of apparatus.

(ii) Name a suitable piece of apparatus which could be used to measure these volumes.

..... [1]

(iii) In **(a)(ii)** you circled an anomalous point. This was caused by the student incorrectly making one of the sucrose solutions.

Suggest the error made by the student that caused this anomaly.

.....

.....

..... [1]

(d) The student recorded the observed angle of rotation, α_{obs}, for a sucrose solution of unknown concentration as +3.75.

Determine the concentration of this sucrose solution in $mol\,dm^{-3}$.
[M_r sucrose: 342]

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

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(e) The glass cell of 10 cm length is expensive, so one cell is used for all the solutions that are placed in the polarimeter.

Suggest how you would ensure that the concentration of solution in the cell is accurate **each time** the cell is used for the different sucrose solutions.

.....

.....

..... [1]

(f) Concentration of sucrose is the independent variable in this polarimeter experiment.

The glass cell of 10 cm length is replaced by a glass cell of 20 cm length. The 20 cm glass cell is filled with 0.0750 g cm^{-3} sucrose solution.

Predict the value for the observed angle of rotation, α_{obs}, for the sucrose solution of concentration 0.0750 g cm^{-3} when the 20 cm cell is used. Explain your answer.

predicted value = ...

explanation .....

.....

[2]

(g) Before the angles of rotation of the sucrose solutions are measured, the glass cell is first filled with distilled water and the angle of rotation measured.

Explain why this measurement is taken.

.....

..... [1]

[Total: 18]

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