Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

0829943846

CHEMISTRY **9701/52**

Paper 5 Planning, Analysis and Evaluation **May/June 2018**

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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[Turn over

1 When concentrated iron(III) chloride is added to water at just below boiling point, a reaction occurs and produces Fe_2O_3, seen as a red colour in the water. This is a 'sol' of Fe_2O_3. A sol contains particles that are insoluble but do not form a precipitate.

A student prepared a concentrated solution of iron(III) chloride by dissolving $FeCl_3.6H_2O(s)$ in distilled water.

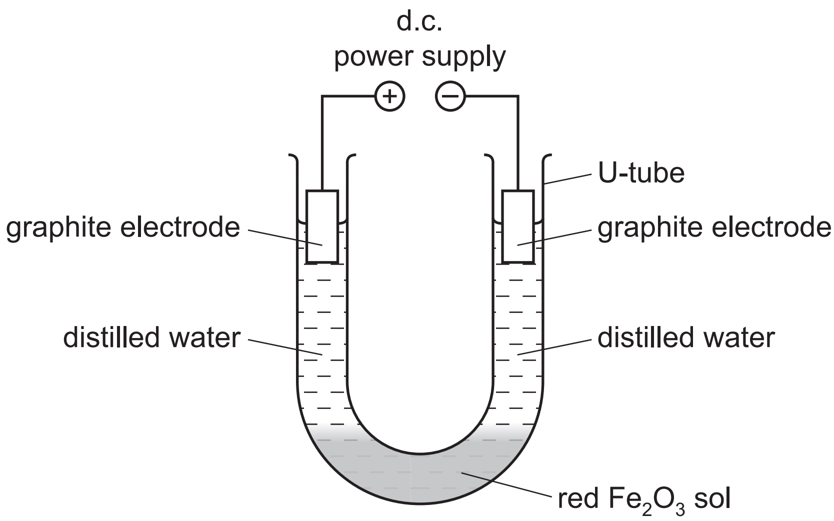
(a) Hazard information for hydrated iron(III) chloride is given.

For this hazard, state a precaution, other than eye protection and a lab coat, that the student could take when preparing a solution of concentrated iron(III) chloride.

hazard: solid $FeCl_3.6H_2O$ is irritating to the skin

precaution .... [1]

Particles of a sol can be positively or negatively charged. The student used the experimental set-up shown to confirm that the Fe_2O_3 sol particle is positively charged.



(b) The student placed a few cm^3 of the sol at the bottom of the U-tube and poured $10\,cm^3$ of distilled water into each side of the U-tube, without disturbing the sol. The two layers of distilled water were colourless at the beginning of the experiment. Graphite electrodes were inserted and a current was passed. After 30 minutes a difference was noted between the distilled water in the two sides of the U-tube.

Predict the colour of the distilled water in both sides of the U-tube after 30 minutes, if the Fe_2O_3 sol particle is positively charged.

observation in side with positive electrode ....

....

observation in side with negative electrode ....

....
[1]

Salt solutions can be added to sols to cause them to precipitate. This method is used in water purification.

(c) The student made up 100.0 cm^3 of standard solutions containing 0.100 $mol\,dm^{-3}$ of the following ions.

$K^+(aq)$ $Mg^{2+}(aq)$ $Al^{3+}(aq)$ $Cl^-(aq)$ $SO_4^{2-}(aq)$ $PO_4^{3-}(aq)$

(i) What mass of solid potassium sulfate, K_2SO_4, did the student use to make up exactly 100.0 cm^3 of 0.100 $mol\,dm^{-3}$ $SO_4^{2-}(aq)$?
[A_r: K, 39.1; S, 32.1; O, 16.0]

mass of K_2SO_4 = ... g [1]

(ii) Describe how the student should have accurately prepared this volume of standard solution from a sample of K_2SO_4 of mass calculated in **(c)(i)**.

....

....

....

....

....

.... [2]

(d) The student carried out an experiment to precipitate the Fe_2O_3 sol, using 0.100 $mol\,dm^{-3}$ $K_2SO_4(aq)$. Only one drop of $K_2SO_4(aq)$ was needed for the complete precipitation of 10.0 cm^3 Fe_2O_3 sol.

Calculate how many moles of SO_4^{2-} were added. Assume that one drop is 0.05 cm^3.

moles of SO_4^{2-} added = ... mol [1]

(e) The student decided to dilute the standard solution of 0.100 mol dm^{-3} K_2SO_4 to make 50.0 cm^3 of 0.0100 mol dm^{-3} K_2SO_4(aq).

(i) Calculate the volume of standard solution required to make exactly 50.0 cm^3 of 0.0100 mol dm^{-3} K_2SO_4(aq).

volume of standard K_2SO_4(aq) = ... cm^3 [1]

(ii) Name a piece of apparatus that could be used to measure accurately the volume of solution calculated in **(e)(i)**.

.... [1]

(f) In an alternative method, 50.0 cm^3 of 0.0100 mol dm^{-3} K_2SO_4(aq) could be prepared by using 0.0872 g of K_2SO_4.

Explain why the dilution method used by the student to prepare 50.0 cm^3 of 0.0100 mol dm^{-3} K_2SO_4(aq) is the more accurate of the two methods.

....

....

.... [1]

(g) The student carried out experiments to investigate how much of a particular salt solution was required to fully precipitate all the Fe_2O_3 sol in a 1000 cm^3 sample. The salt solutions used were all of concentration 0.0100 mol dm^{-3} with respect to the ion being investigated.

Experiment 1

identity of salt solution	charge on anion	minimum amount of anion required for complete precipitation of 1000 cm^3 sol / mol
KCl	–1	1.02×10^{-1}
K_2SO_4	–2	3.25×10^{-4}
K_3PO_4	–3	8.56×10^{-5}

Experiment 2

identity of salt solution	charge on cation	minimum amount of cation required for complete precipitation of 1000 cm^3 sol / mol
KCl	+1	1.02×10^{-1}
$MgCl_2$	+2	1.10×10^{-1}
$AlCl_3$	+3	1.15×10^{-1}

(i) Describe the effect of changing the charge on the anion from –1 to –2 to –3 on the precipitation of the Fe_2O_3 sol in Experiment 1.

....

.... [1]

(ii) Identify the independent variable in Experiment 2.

.... [1]

(iii) Arsenic sulfide, As_2S_3, is highly toxic and should be removed from drinking water.

The Fe_2O_3 sol particles are positively charged.

The As_2S_3 sol particles are negatively charged.

Based on the student's results, which salt used in either Experiment 1 or Experiment 2 would be the most effective at removing As_2S_3 from drinking water?
Explain your answer.

salt ....

explanation ....

....
[2]

[Total: 13]

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2 Water boils when the pressure of its vapour above the liquid surface is equal to the atmospheric pressure. When substances are dissolved in water, the vapour pressure of the water is reduced and its boiling point is increased.

The increase in boiling point is known as the boiling point elevation, ΔT, which is the difference between the boiling point of a solution and the boiling point of pure water. ΔT is usually small, often less than 1 °C.

When glucose is dissolved in 1 kg of water, the relationship between ΔT and the number of moles of glucose dissolved is as shown.

$$\Delta T = K_b \times Z$$

K_b is the boiling point constant of pure water

$Z = \dfrac{\text{number of moles of glucose}}{\text{mass of water, in kg}}$ in mol kg^{-1}

(a) Use the information above to explain why lowering the vapour pressure of a liquid increases the temperature at which it boils.

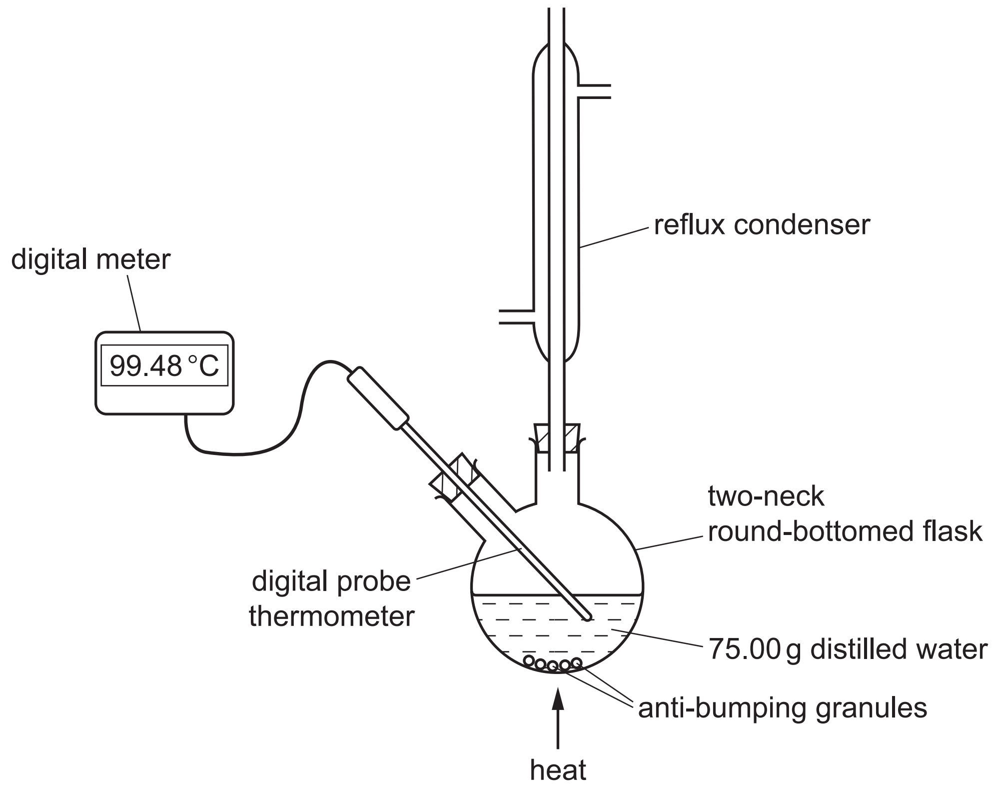
....

....

....

.... [1]

A student carries out an experiment to determine the boiling point constant, K_b, for water. The student uses anhydrous glucose, $C_6H_{12}O_6$, as the solute because it is non-volatile and very soluble in water.
The experimental set-up the student uses is shown.



(b) Show, using a labelled arrow, where the cooling water enters the reflux condenser. [1]

(c) A digital probe thermometer is used as shown in the diagram.

Explain why a normal laboratory glass thermometer would **not** be suitable.

....

.... [1]

The student follows this procedure.

1. Transfer 75.00 g of distilled water to the round-bottomed flask.
2. Add anti-bumping granules to the distilled water to prevent violent, uneven boiling.
3. Heat the distilled water until it boils and record the highest stable temperature.
4. Stop heating and allow the distilled water to cool to room temperature.
5. Remove the reflux condenser and add about 1 g of anhydrous glucose, measured accurately.
6. Replace the reflux condenser and heat the solution until it boils, noting the highest stable temperature.
7. Repeat steps 4 to 6, each time adding approximately 1 g more of anhydrous glucose, accurately weighed, until sufficient readings are taken.

(d) In step 4, the heating is stopped and the distilled water allowed to cool from its boiling point, before removing the reflux condenser.

Apart from for safety reasons, explain why this is essential.

....

.... [1]

(e) At 101 kPa (1 atm), distilled water is known to boil at 100.00 °C.

Suggest why the boiling point of distilled water in this experiment was found to be 99.48 °C.

Assume that the digital probe thermometer was reading correctly.

....

.... [1]

(f) **(i)** The student constructed the table shown to record the results for this experiment.

Complete columns **C** and **D** to **three** significant figures and column **E** to **two** decimal places.
[The M_r of glucose is 180.]

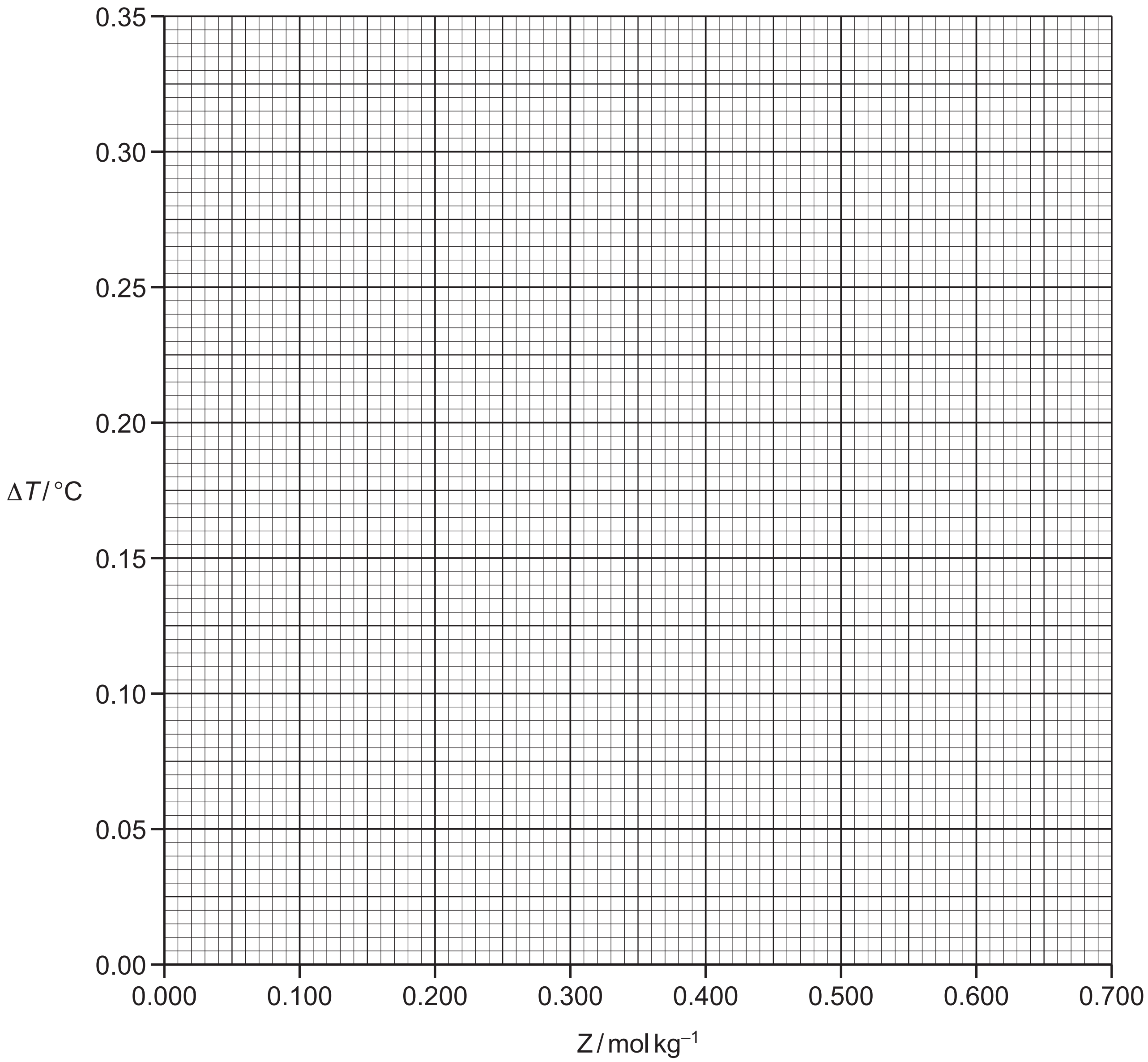
$$Z = \frac{\text{moles of glucose}}{\text{mass of water, in kg}}$$

A	B	C	D	E
mass of glucose / g	boiling point / °C	amount of glucose in 75.00 g of water / mol	Z / mol kg^{-1}	ΔT / °C
0.00	99.48	0	0	0.00
1.22	99.53	0.00678	$\frac{0.00678}{0.075} = 0.0904$	0.05
2.54	99.58			
3.46	99.61			
4.37	99.65			
5.01	99.67			
5.93	99.70			
7.01	99.72			
7.95	99.78			
8.78	99.81			

[3]

You may use the space below for any working.

(ii) Plot a graph on the grid to show the relationship between ΔT and the amount of glucose in 1 kg of water, Z.
Use a cross (×) to plot each data point. Draw a line of best fit.



[2]

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

(g) Use the graph and the equation to determine the boiling point constant, K_b, for water. Give this value to **three** significant figures and state the units.

$$\Delta T = K_b \times Z$$

State the co-ordinates of both points you used in your calculation.

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

K_b = ...

units = ...
[3]

ΔT actually depends on the number of dissolved particles in solution.

(h) **(i)** The experiment was repeated using solid from a bottle that was labelled glucose, $C_6H_{12}O_6$, but actually contained sucrose, $C_{12}H_{22}O_{11}$. Sucrose is non-volatile and very soluble in water.

What would be the effect of this on the value the student obtained for K_b?

Explain your answer.

....

.... [1]

(ii) The student used distilled water to dissolve the glucose.

Suggest why the student did not use tap water.

....

.... [1]

(iii) The student repeated this experiment using sodium chloride as the solute. The student found their calculated value of K_b was **twice** the calculated value of that obtained with glucose.

Suggest a reason for this.

....

.... [1]

[Total: 17]