

CANDIDATE
NAME

--

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

CHEMISTRY

9701/51

Paper 5 Planning, Analysis and Evaluation

May/June 2014

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 **10** printed pages and **2** blank pages.



- 1 When magnesium nitrate(V) is heated, it decomposes to form magnesium oxide, nitrogen(IV) oxide and oxygen.

Nitrogen(IV) oxide is an acidic gas that reacts readily and completely with alkalis.

You are to plan a **single** experiment to confirm that the molar quantities of magnesium oxide, nitrogen(IV) oxide and oxygen produced agree with the equation for the thermal decomposition of magnesium nitrate(V).

The following information gives some of the hazards associated with nitrogen(IV) oxide.

Nitrogen(IV) oxide must not be inhaled. A large dose can be fatal and smaller quantities can have severe effects on breathing, particularly for people who suffer from asthma.

You are provided with anhydrous magnesium nitrate(V) and have access to the usual laboratory equipment and reagents.

- (a) (i) Write an equation for the thermal decomposition of magnesium nitrate(V).

..... [1]

- (ii) Calculate the mass of magnesium oxide and volumes of nitrogen(IV) oxide and oxygen produced under room conditions when 1 mole of magnesium nitrate(V) is heated.

[A_r : O, 16.0; Mg, 24.3]

You should assume that one mole of any gas occupies 24.0 dm^3 under room conditions.

[1]

- (b) (i)** Draw and label a diagram of the apparatus and experimental set-up you would use. The set-up needs to be capable of absorbing the nitrogen(IV) oxide and collecting the oxygen separately and in sequence.

[4]

- (ii)** State the volume of the gas collector to be used to collect oxygen in **(i)**. Calculate a mass of magnesium nitrate(V) to be heated that would produce a stated volume of oxygen appropriate for the collector.

[A_r : N, 14.0; O, 16.0; Mg, 24.3]

You should assume that one mole of any gas occupies 24.0 dm^3 under room conditions.

[1]

(c) List the measurements you would make when carrying out the experiment.

.....

.....

.....

.....

.....

..... [3]

(d) (i) How could you make sure that the magnesium nitrate(V) had completely decomposed in the experiment?

.....

.....

..... [1]

(ii) To make sure that the volume of gas measured is accurate, what should you do before taking the measurement?

.....

..... [1]

(e) Explain how you would use the results of the experiment to confirm that the decomposition had occurred according to the molar ratios in the equation.

.....

.....

.....

.....

.....

..... [2]

(f) What precautions would you take to make sure that the experiment could be performed safely?

.....

.....

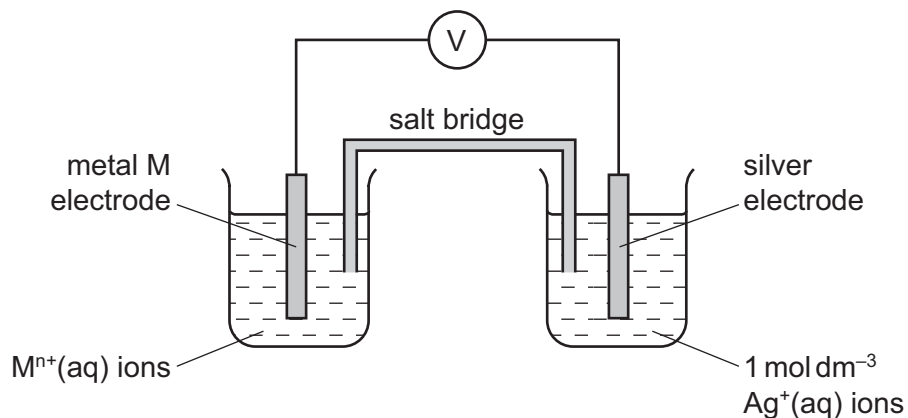
.....

..... [1]

[Total: 15]

- 2 An experiment was set up to investigate how the cell potential of a cell containing a metal, M, in contact with an aqueous solution of its ions, $M^{n+}(aq)$ (where $n = 1, 2$ or 3), changed as $M^{n+}(aq)$ was diluted.

Since a standard hydrogen half-cell was not available, a standard half-cell consisting of silver in contact with a 1 mol dm^{-3} solution of silver ions was used to connect to the half-cell with M in contact with $M^{n+}(aq)$.



The metal electrodes of the two half-cells were connected via a voltmeter, reading to two decimal places. This was used to measure the cell potential of the cell.

The cell potential was measured for various concentrations of $M^{n+}(aq)$ and the results obtained are shown in the table below.

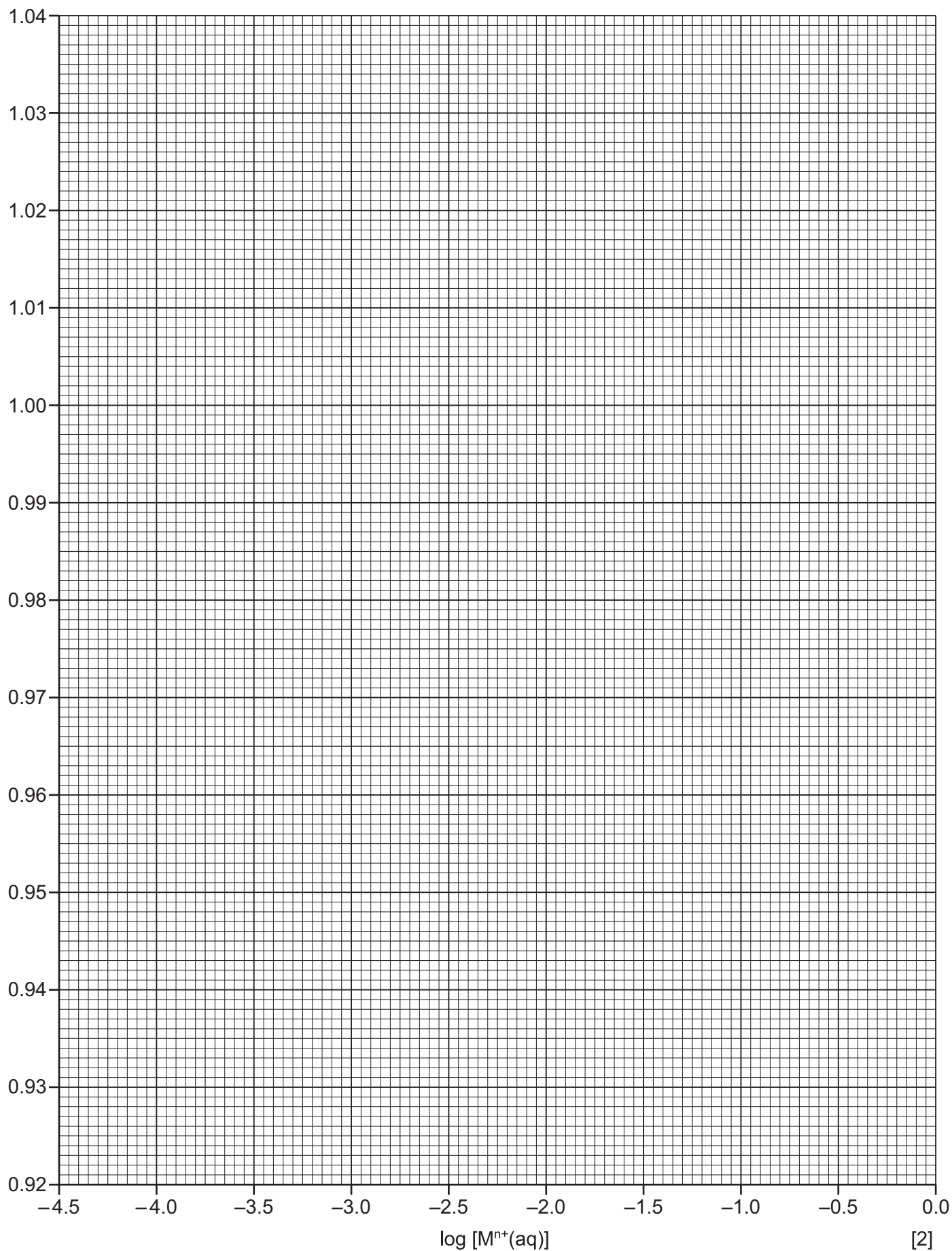
- (a) Complete the third column of the table below. Give each answer to two decimal places.

concentration of $M^{n+}(aq) / \text{mol dm}^{-3}$	cell potential / V	$\log [M^{n+}(aq)]$
5.00×10^{-1}	0.94	
1.00×10^{-1}	0.96	
4.00×10^{-2}	0.97	
1.00×10^{-2}	0.99	
5.00×10^{-3}	1.00	
2.00×10^{-3}	1.01	
8.00×10^{-4}	1.02	
2.00×10^{-4}	1.04	

[2]

- (b) Plot a graph to show the relationship between $\log [M^{n+}(aq)]$ and the cell potential measured and draw the line of best fit.

cell potential / V



[2]

- (c) Are there any anomalous points on your graph? If so, circle those points. Give a reason for your answer.

.....

 [2]

- (d) It is known that the cell potential of a cell, E , is related to the standard electrode potential, E° , by the equation:

$$E = E^\circ - \frac{0.06 \log [M^{n+}(aq)]}{n}$$

- (i) Use your graph to determine the charge, n , of the M^{n+} ions. Draw appropriate lines on your graph to enable you to calculate its slope and show in the space below, how n was calculated.

[3]

- (ii) Use your graph to determine the standard electrode potential, E° , of the cell.

.....
 [1]

- (e) The standard electrode potential for silver is +0.80 V.
 Calculate the standard electrode potential for the metal, M. Use the data given on page 12 to suggest the identity of M.

.....

 [1]

(f) Write an overall equation for the cell reaction which is taking place.

..... [1]

(g) The solutions contained in the two half-cells must be connected using a salt bridge.

(i) Why is a salt bridge necessary?

.....
..... [1]

(ii) Which (if any) of the following salts would be suitable to use in the salt bridge:

potassium chloride, potassium nitrate, potassium sulfate?

If you consider any to be unsuitable, explain why.

.....
.....
..... [2]

[Total: 15]

E° in decreasing order of oxidising power

Electrode reaction	E°/V
$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.87
$S_2O_8^{2-} + 2e^- \rightleftharpoons 2SO_4^{2-}$	+2.01
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1.77
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.52
$PbO_2 + 4H^+ + 2e^- \rightleftharpoons Pb^{2+} + 2H_2O$	+1.47
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.07
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+0.81
$Ag^+ + e^- \rightleftharpoons Ag$	+0.80
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77
$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$	+0.40
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$	+0.17
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+0.15
$S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$	+0.09
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	-0.13
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	-0.14
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	-0.44
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	-0.76
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	-2.38
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	-2.87
$K^+ + e^- \rightleftharpoons K$	-2.92

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included the publisher will be pleased to make amends at the earliest possible opportunity.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

CANDIDATE
NAME

--

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

CHEMISTRY

9701/52

Paper 5 Planning, Analysis and Evaluation

May/June 2014

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.

- 1 The liquids trichloromethane and water separate into two immiscible layers when shaken together and allowed to stand.
Ammonia can dissolve in both of these layers. The distribution of ammonia between these two solvents is called partition, where the concentration of ammonia in each solvent will be different. The partition coefficient represents the ratio of the distribution.

You are to plan an experiment, using a titration with sulfuric acid, to determine the value of the partition coefficient of ammonia between water and trichloromethane at room temperature.

The following information gives some of the hazards associated with trichloromethane and ammonia.

Trichloromethane:

Anaesthetic if inhaled. Dangerously irritating to the respiratory system.

Ammonia:

An aqueous solution with a concentration of less than 3 mol dm^{-3} may cause harm to eyes or in a cut. At greater concentrations aqueous ammonia should not be inhaled and it causes irritation to the eyes and skin.

You are provided with the following.

- trichloromethane
- aqueous ammonia of concentration 5.00 mol dm^{-3}
- sulfuric acid, of concentration $0.500 \text{ mol dm}^{-3}$
- distilled water for dilution of aqueous ammonia

- (a) Explain why ammonia is likely to be more soluble in water than in trichloromethane.

.....

.....

.....

..... [2]

- (b) Define the partition coefficient, $K_{\text{partition}}$, for ammonia between water and trichloromethane. State whether the partition coefficient you have defined will be greater or less than 1.

[1]

- (c) In the experiment, explain whether it is important that the volumes of water and trichloromethane are the same.

.....
.....
.....
..... [1]

- (d) Write an equation for the reaction of aqueous ammonia and sulfuric acid.

..... [1]

- (e) (i) The partition coefficient for ammonia distributed between water and trichloromethane is approximately 25.
Calculate the concentration of aqueous ammonia that should be used so that a 25.0 cm^3 sample of the aqueous ammonia layer would require approximately $24.0\text{--}26.0\text{ cm}^3$ of 0.500 mol dm^{-3} sulfuric acid for complete neutralisation.
Then state the factor by which the 5.00 mol dm^{-3} aqueous ammonia should be diluted to give that concentration.

[2]

- (ii) Describe, in detail, how you would dilute 5.00 mol dm^{-3} aqueous ammonia to make 250 cm^3 of aqueous ammonia ready for use in the experiment.

.....
.....
.....
.....
.....
.....
..... [2]

- (f) Other than the use of eye protection and gloves, state one safety precaution you would take while setting up the experiment.

.....

.....

..... [1]

- (g) State a suitable indicator for use in the titration of a sample taken from the experiment. Explain your answer.

.....

.....

.....

..... [2]

- (h) It is unnecessary to titrate both layers of the partition. Explain why it would be better to titrate a sample of the aqueous layer rather than the trichloromethane layer.

.....

.....

.....

..... [1]

- (i) Once a mean titre has been calculated, outline the steps you would take to calculate the partition coefficient.

.....

.....

.....

.....

.....

..... [2]

[Total: 15]

QUESTION 2 STARTS ON THE NEXT PAGE.

- 2 Nitrogen(II) oxide, NO, can be oxidised by ozone, O₃, in the atmosphere to form nitrogen(IV) oxide, NO₂.

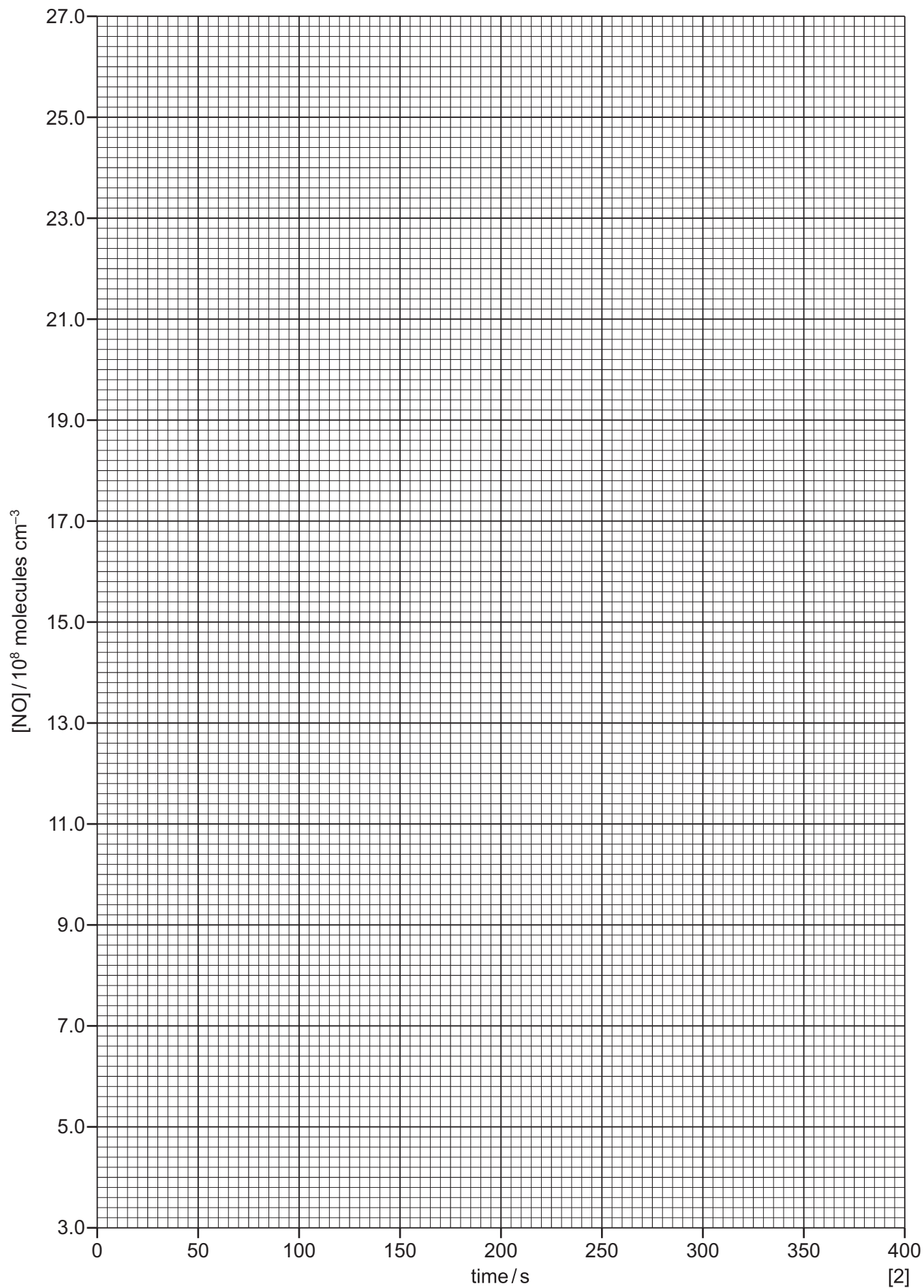
It is possible to simulate this process in the laboratory to measure the rate at which this reaction takes place.

In this experiment, nitrogen(II) oxide is reacted with ozone. Since the concentration of nitrogen(II) oxide, [NO], in the air is very low, specialist equipment is required and [NO] oxide is measured as the number of molecules present in a volume of 1 cm³.

The results obtained from the experiment are shown below.

time / s	concentration of NO / 10 ⁸ molecules cm ⁻³
0	27.0
30	21.9
60	17.7
90	14.4
120	13.2
150	9.45
180	7.66
210	6.21
240	5.03
270	4.08
300	3.31

(a) Use the results obtained to plot a graph to show the relationship between [NO] and time.



- (b) On your graph circle the **single** result that you consider to be the most anomalous. Suggest a reason why anomalous results may occur during an experiment to measure the rate of a reaction.

.....
.....
..... [2]

- (c) Use construction lines at concentrations of nitrogen(II) oxide equal to 13.5×10^8 molecules cm^{-3} and 6.75×10^8 molecules cm^{-3} to determine the order of reaction with respect to nitrogen(II) oxide.

Show the construction lines on your graph and your working.

[3]

- (d) (i) Use your graph to calculate the initial rate of the reaction.

[2]

- (ii) In the reaction between ozone and nitrogen(II) oxide the order of reaction with respect to ozone is 1.

In the experiment the initial concentration of ozone used was 4×10^{11} molecules cm^{-3} .

Calculate the value of the rate constant for the reaction and give its units.

[2]

- (e) 1 mole contains 6.02×10^{23} particles.

Convert the initial rate in (d)(i) to a value with units of $\text{mol dm}^{-3} \text{s}^{-1}$.

(If you have no answer to (d)(i) you may use 3.0×10^5 as the value of the initial rate.)

[2]

- (f) The concentration of ozone used in the experiment is considerably greater than the concentration of nitrogen(II) oxide.

Explain why this is necessary for the experiment, in order to determine the order with respect to nitrogen(II) oxide.

.....

.....

.....

.....

..... [2]

[Total: 15]

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included the publisher will be pleased to make amends at the earliest possible opportunity.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.

CANDIDATE
NAME

--

CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

5693031167



CHEMISTRY

9701/53

Paper 5 Planning, Analysis and Evaluation

May/June 2014

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 **10** printed pages and **2** blank pages.

- 1 When magnesium nitrate(V) is heated, it decomposes to form magnesium oxide, nitrogen(IV) oxide and oxygen.

Nitrogen(IV) oxide is an acidic gas that reacts readily and completely with alkalis.

You are to plan a **single** experiment to confirm that the molar quantities of magnesium oxide, nitrogen(IV) oxide and oxygen produced agree with the equation for the thermal decomposition of magnesium nitrate(V).

The following information gives some of the hazards associated with nitrogen(IV) oxide.

Nitrogen(IV) oxide must not be inhaled. A large dose can be fatal and smaller quantities can have severe effects on breathing, particularly for people who suffer from asthma.

You are provided with anhydrous magnesium nitrate(V) and have access to the usual laboratory equipment and reagents.

- (a) (i) Write an equation for the thermal decomposition of magnesium nitrate(V).

..... [1]

- (ii) Calculate the mass of magnesium oxide and volumes of nitrogen(IV) oxide and oxygen produced under room conditions when 1 mole of magnesium nitrate(V) is heated.

[A_r : O, 16.0; Mg, 24.3]

You should assume that one mole of any gas occupies 24.0 dm^3 under room conditions.

[1]

- (b) (i) Draw and label a diagram of the apparatus and experimental set-up you would use. The set-up needs to be capable of absorbing the nitrogen(IV) oxide and collecting the oxygen separately and in sequence.

[4]

- (ii) State the volume of the gas collector to be used to collect oxygen in (i). Calculate a mass of magnesium nitrate(V) to be heated that would produce a stated volume of oxygen appropriate for the collector.

[A_r : N, 14.0; O, 16.0; Mg, 24.3]

You should assume that one mole of any gas occupies 24.0 dm^3 under room conditions.

[1]

(c) List the measurements you would make when carrying out the experiment.

.....

.....

.....

.....

.....

..... [3]

(d) (i) How could you make sure that the magnesium nitrate(V) had completely decomposed in the experiment?

.....

.....

..... [1]

(ii) To make sure that the volume of gas measured is accurate, what should you do before taking the measurement?

.....

..... [1]

(e) Explain how you would use the results of the experiment to confirm that the decomposition had occurred according to the molar ratios in the equation.

.....

.....

.....

.....

.....

..... [2]

(f) What precautions would you take to make sure that the experiment could be performed safely?

.....

.....

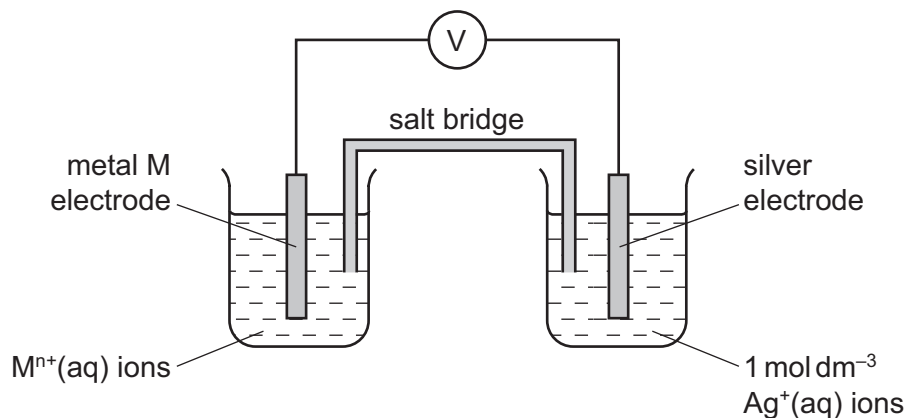
.....

..... [1]

[Total: 15]

- 2 An experiment was set up to investigate how the cell potential of a cell containing a metal, M, in contact with an aqueous solution of its ions, $M^{n+}(aq)$ (where $n = 1, 2$ or 3), changed as $M^{n+}(aq)$ was diluted.

Since a standard hydrogen half-cell was not available, a standard half-cell consisting of silver in contact with a 1 mol dm^{-3} solution of silver ions was used to connect to the half-cell with M in contact with $M^{n+}(aq)$.



The metal electrodes of the two half-cells were connected via a voltmeter, reading to two decimal places. This was used to measure the cell potential of the cell.

The cell potential was measured for various concentrations of $M^{n+}(aq)$ and the results obtained are shown in the table below.

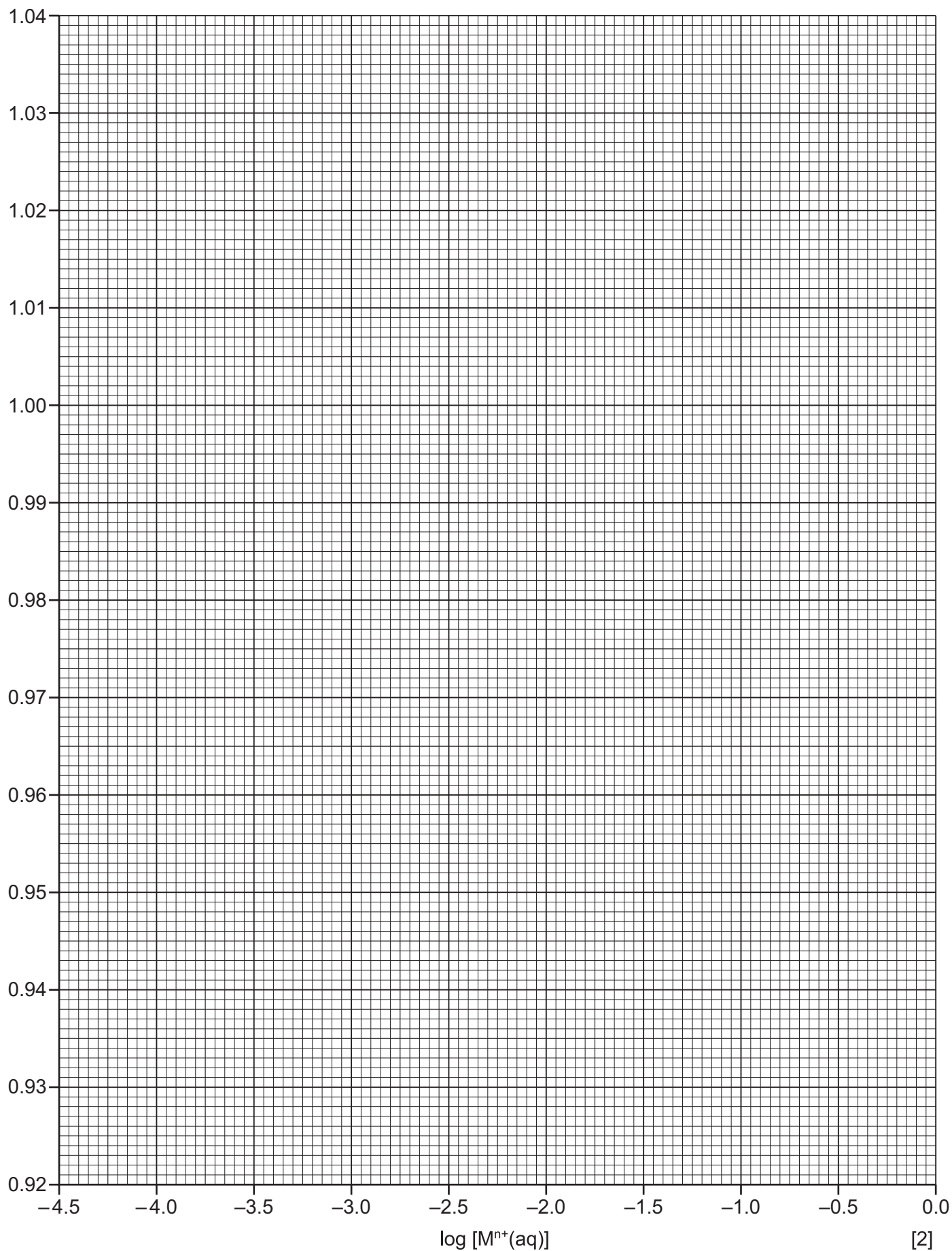
- (a) Complete the third column of the table below. Give each answer to two decimal places.

concentration of $M^{n+}(aq) / \text{mol dm}^{-3}$	cell potential / V	$\log [M^{n+}(aq)]$
5.00×10^{-1}	0.94	
1.00×10^{-1}	0.96	
4.00×10^{-2}	0.97	
1.00×10^{-2}	0.99	
5.00×10^{-3}	1.00	
2.00×10^{-3}	1.01	
8.00×10^{-4}	1.02	
2.00×10^{-4}	1.04	

[2]

- (b) Plot a graph to show the relationship between $\log [M^{n+}(aq)]$ and the cell potential measured and draw the line of best fit.

cell potential / V



[2]

- (c) Are there any anomalous points on your graph? If so, circle those points. Give a reason for your answer.

.....

 [2]

- (d) It is known that the cell potential of a cell, E , is related to the standard electrode potential, E° , by the equation:

$$E = E^\circ - \frac{0.06 \log [M^{n+}(aq)]}{n}$$

- (i) Use your graph to determine the charge, n , of the M^{n+} ions. Draw appropriate lines on your graph to enable you to calculate its slope and show in the space below, how n was calculated.

[3]

- (ii) Use your graph to determine the standard electrode potential, E° , of the cell.

.....
 [1]

- (e) The standard electrode potential for silver is +0.80 V.
 Calculate the standard electrode potential for the metal, M. Use the data given on page 12 to suggest the identity of M.

.....

 [1]

(f) Write an overall equation for the cell reaction which is taking place.

..... [1]

(g) The solutions contained in the two half-cells must be connected using a salt bridge.

(i) Why is a salt bridge necessary?

.....
..... [1]

(ii) Which (if any) of the following salts would be suitable to use in the salt bridge:

potassium chloride, potassium nitrate, potassium sulfate?

If you consider any to be unsuitable, explain why.

.....
.....
..... [2]

[Total: 15]

E° in decreasing order of oxidising power

Electrode reaction	E°/V
$F_2 + 2e^- \rightleftharpoons 2F^-$	+2.87
$S_2O_8^{2-} + 2e^- \rightleftharpoons 2SO_4^{2-}$	+2.01
$H_2O_2 + 2H^+ + 2e^- \rightleftharpoons 2H_2O$	+1.77
$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O$	+1.52
$PbO_2 + 4H^+ + 2e^- \rightleftharpoons Pb^{2+} + 2H_2O$	+1.47
$Cl_2 + 2e^- \rightleftharpoons 2Cl^-$	+1.36
$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightleftharpoons 2Cr^{3+} + 7H_2O$	+1.33
$Br_2 + 2e^- \rightleftharpoons 2Br^-$	+1.07
$NO_3^- + 2H^+ + e^- \rightleftharpoons NO_2 + H_2O$	+0.81
$Ag^+ + e^- \rightleftharpoons Ag$	+0.80
$Fe^{3+} + e^- \rightleftharpoons Fe^{2+}$	+0.77
$I_2 + 2e^- \rightleftharpoons 2I^-$	+0.54
$O_2 + 2H_2O + 4e^- \rightleftharpoons 4OH^-$	+0.40
$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
$SO_4^{2-} + 4H^+ + 2e^- \rightleftharpoons SO_2 + 2H_2O$	+0.17
$Sn^{4+} + 2e^- \rightleftharpoons Sn^{2+}$	+0.15
$S_4O_6^{2-} + 2e^- \rightleftharpoons 2S_2O_3^{2-}$	+0.09
$2H^+ + 2e^- \rightleftharpoons H_2$	0.00
$Pb^{2+} + 2e^- \rightleftharpoons Pb$	-0.13
$Sn^{2+} + 2e^- \rightleftharpoons Sn$	-0.14
$Fe^{2+} + 2e^- \rightleftharpoons Fe$	-0.44
$Zn^{2+} + 2e^- \rightleftharpoons Zn$	-0.76
$Mg^{2+} + 2e^- \rightleftharpoons Mg$	-2.38
$Ca^{2+} + 2e^- \rightleftharpoons Ca$	-2.87
$K^+ + e^- \rightleftharpoons K$	-2.92

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included the publisher will be pleased to make amends at the earliest possible opportunity.

Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.