Cambridge International A Level

Cambridge International Examinations
Cambridge International Advanced Level

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.

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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]

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(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]

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[Turn over

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

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.....

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.....

.....

..... [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.

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..... [2]

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

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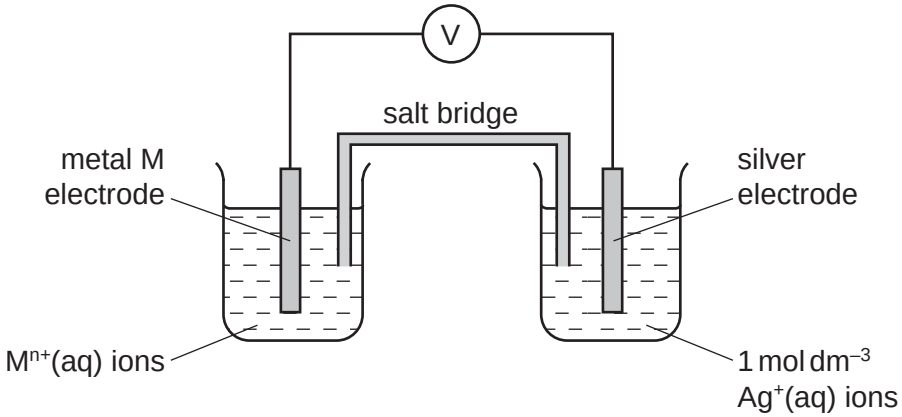
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.....

..... [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.

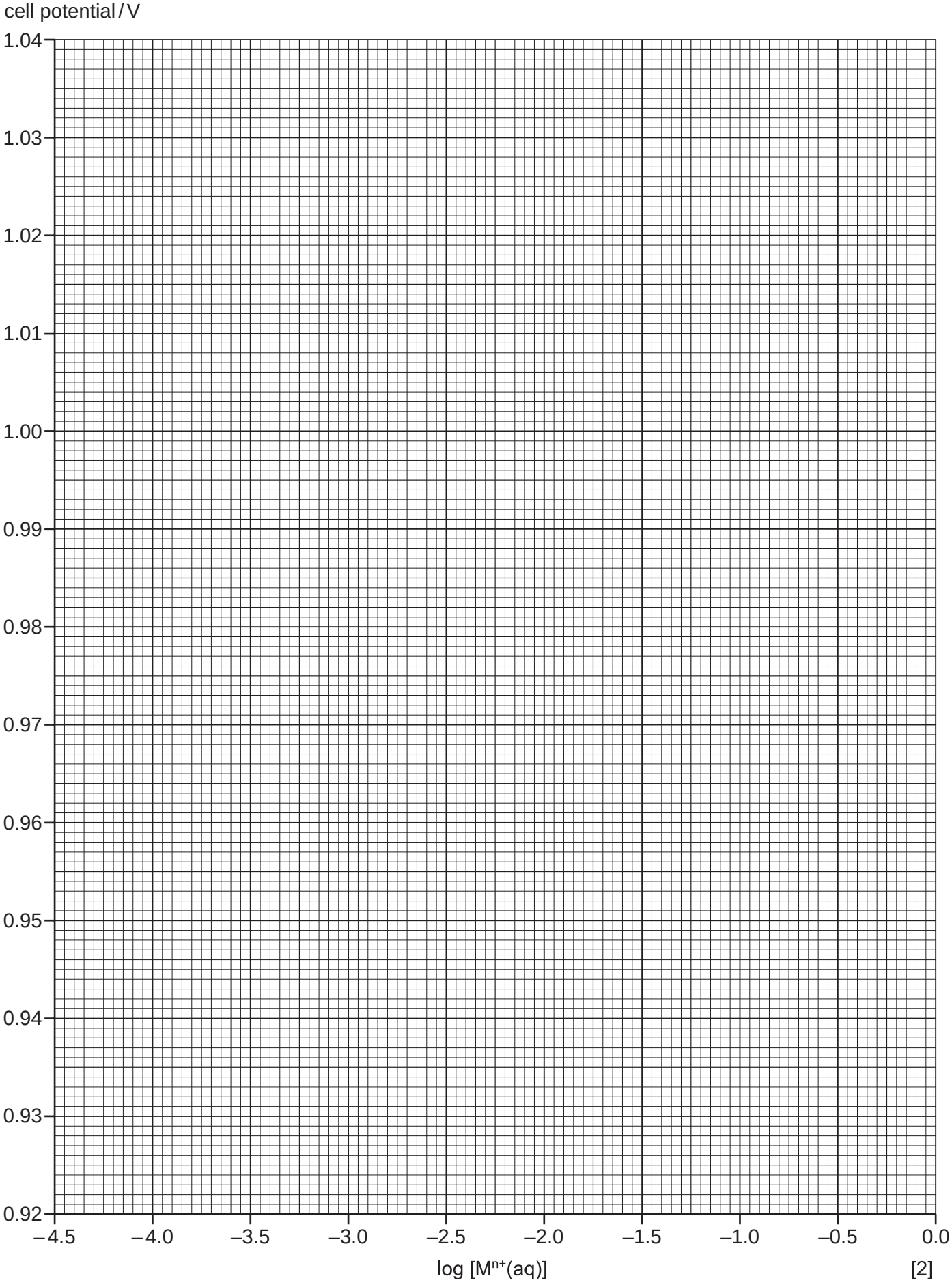
(a) Complete the third column of the table below. Give each answer to two decimal places.

concentration of $M^{n+}(aq)$ / 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]

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(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.



[2]

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[Turn over

(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, $E^{\ominus}$, by the equation:

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

(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, $E^{\ominus}$, 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]

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(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]

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$E^{\ominus}$ in decreasing order of oxidising power

Electrode reaction			$E^{\ominus}$/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

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