Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	
CENTRE NUMBER	
CANDIDATE NUMBER	

7333387163

CHEMISTRY **9701/35**

Paper 3 Advanced Practical Skills 1 **May/June 2015**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
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.

Qualitative Analysis Notes are printed on pages 14 and 15.

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.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **13** printed pages and **3** blank pages.

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CAMBRIDGE International Examinations

1 In this experiment you will determine the formula of iron(III) ammonium sulfate, $FeNH_4(SO_4)_2.xH_2O$, where ***x*** is the number of molecules of water of crystallisation.

A known mass of this iron(III) compound reacted with excess acidified potassium iodide to produce iodine. You will determine the amount of iodine produced by titrating the mixture with sodium thiosulfate.

FA 1 is 0.900 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
FA 2 is a solution of iodine, I_2, produced as outlined in the paragraph above.
starch indicator

(a) Method

Diluting FA 1

- Pipette 25.0 cm^3 of **FA 1** into the 250 cm^3 volumetric (graduated) flask.
- Make the solution up to the mark using distilled water.
- Shake the flask to mix the solution thoroughly before using it for your titrations.
- Label this diluted solution of sodium thiosulfate **FA 3**.
- Rinse the pipette with distilled water.

Keep FA 1 for use in Question 3.

Titration

- Fill the burette with **FA 3**.
- Use the pipette to transfer 25.0 cm^3 of **FA 2** into a conical flask.
- Add **FA 3** from the burette into the conical flask until the mixture becomes pale yellow.
- Then add 10 drops of starch indicator to give a blue-black colour.
- Continue adding **FA 3** until this blue-black colour disappears. This is the end-point of the titration.
- Perform a **rough titration** and record your burette readings in the space below.

The rough titre is ..... cm^3.

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable table below, all of your burette readings and the volume of **FA 3** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

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(b) From your accurate titration results, obtain a suitable value to be used in your calculations. Show clearly how you obtained this value.

25.0 cm^3 of **FA 2** required ..... cm^3 of **FA 3**. [1]

(c) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Using information on page 2, calculate the concentration, in mol dm^{-3}, of sodium thiosulfate in **FA 3**.

concentration of $Na_2S_2O_3$ in **FA 3** = ... mol dm^{-3}

(ii) Calculate the number of moles of sodium thiosulfate present in the volume of **FA 3** calculated in **(b)**.

moles of $Na_2S_2O_3$ = ... mol

(iii) Use the equation below to calculate the number of moles of iodine that reacted with the sodium thiosulfate in **(ii)**.

$$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$$

moles of I_2 = ... mol

(iv) Calculate the concentration of I_2, in mol dm^{-3}, in **FA 2**.

concentration of I_2 = ... mol dm^{-3}

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(v) The iodine in **FA 2** was produced by the reaction of iron(III) ions with excess potassium iodide. Balance the equation for this reaction.

..... $Fe^{3+}(aq)$ + ... $I^{-}(aq)$ → ..... $Fe^{2+}(aq)$ + ... $I_2(aq)$

Use your answer to **(iv)** and this equation to calculate the number of moles of iron(III) ions that reacted to produce the iodine in 1.00 dm^3 of **FA 2**.

moles of Fe^{3+} = ... mol

(vi) The formula of the iron(III) compound is $FeNH_4(SO_4)_2.\boldsymbol{x}H_2O$.
38.56 g of this compound was weighed out and added to excess aqueous acidified potassium iodide.
FA 2 was made by making the resulting solution of iodine up to 1.00 dm^3 with distilled water.

Use this information and your answer to **(v)** to calculate the number of moles of water of crystallisation, ***x***, in one mole of the iron(III) compound.

[A_r: H, 1.0; N, 14.0; O, 16.0; S, 32.1; Fe, 55.8]

x = ...
[6]

[Total: 14]

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2 In this experiment you will determine the enthalpy change, ΔH, for the reaction of zinc with iron(II) sulfate.

$$Zn(s) + FeSO_4(aq) \rightarrow Fe(s) + ZnSO_4(aq)$$

In order to do this, you will determine the enthalpy changes for the reactions of zinc and iron with aqueous copper(II) sulfate. Excess of the two metals will be used during the determinations.

Then you will use Hess' Law to calculate the enthalpy change for the reaction above.

FA 4 is zinc, Zn.
FA 5 is iron, Fe.
FA 6 is 0.500 mol dm^{-3} copper(II) sulfate, $CuSO_4$.

(a) Determination of the enthalpy change for the reaction of zinc, **FA 4**, with aqueous copper(II) sulfate, **FA 6**.

Method

- Support a plastic cup inside the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 6** into the plastic cup.
- Measure and record the initial temperature of the solution in the space below.
- Add all the **FA 4** from the container to the **FA 6** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature. Tilt the cup if necessary to ensure the thermometer bulb is fully immersed.
- Calculate and record the temperature rise.

[3]

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[Turn over

(b) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Calculate the energy produced during this reaction.
[Assume that **4.2 J** are needed to raise the temperature of 1.0 cm^3 of solution by 1.0 °C.]

energy produced = ... J

(ii) Calculate the number of moles of copper(II) sulfate in 25 cm^3 of **FA 6**.

moles of $CuSO_4$ = ... mol

(iii) Calculate the enthalpy change, in $kJ\,mol^{-1}$, for the reaction below.

$$Zn(s) + CuSO_4(aq) \rightarrow Cu(s) + ZnSO_4(aq)$$

enthalpy change = ... $kJ\,mol^{-1}$
sign *value*

[2]

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(c) Determination of the enthalpy change for the reaction of iron, **FA 5**, with aqueous copper(II) sulfate, **FA 6**.

Method

- Support the second plastic cup inside the beaker.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 6** into the plastic cup.
- Measure and record the initial temperature of the solution in the space below.
- Add all the **FA 5** from the container to the **FA 6** in the plastic cup.
- Stir constantly until the maximum temperature is reached.
- Measure and record the maximum temperature. Tilt the cup if necessary to ensure the thermometer bulb is fully immersed.
- Calculate and record the temperature rise.

Keep solution FA 6 for use in Question 3.

[2]

(d) Calculations

Show your working and appropriate significant figures in the final answer to **each** step of your calculations.

(i) Calculate the energy produced during this reaction.
[Assume that **4.2 J** are needed to raise the temperature of 1.0 cm^3 of solution by 1.0 °C.]

energy produced = ... J

(ii) Calculate the enthalpy change, in kJ mol^{-1}, for the reaction below.

$$Fe(s) + CuSO_4(aq) \rightarrow Cu(s) + FeSO_4(aq)$$

enthalpy change = ... kJ mol^{-1}
sign *value*

[2]

(e) Use your values for the enthalpy changes calculated in **(b)(iii)** and **(d)(ii)** to calculate the enthalpy change for the reaction below.

$$Zn(s) + FeSO_4(aq) \rightarrow Fe(s) + ZnSO_4(aq)$$

Show clearly how you obtained your answer by drawing a Hess' Law energy cycle.

(If you were unable to calculate the enthalpy changes, assume that the value in **(b)(iii)** is $-210\,kJ\,mol^{-1}$ and the value in **(d)(ii)** is $-144\,kJ\,mol^{-1}$. Note: these are not the correct values.)

enthalpy change = ... $kJ\,mol^{-1}$
sign *value*

[2]

(f) **(i)** Calculate the maximum percentage error in the temperature **rise** in **(c)**.

percentage error = ... %

(ii) Apart from using a more accurately calibrated thermometer, suggest **one** improvement that could be made to this experiment that would increase the accuracy.

.....

.....

.....

[2]

[Total: 13]

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3 Qualitative Analysis

At each stage of any test you are to record details of the following.

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations**.

You should indicate clearly at what stage in a test a change occurs.
No additional tests for ions present should be attempted.

If any solution is warmed, a boiling tube MUST be used.

Rinse and reuse test-tubes and boiling tubes where possible.

Where reagents are selected for use in a test, the name or correct formula of the element or compound must be given.

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[Turn over

(a) **FA 1**, used in **Question 1**, is an aqueous solution of sodium thiosulfate.
FA 6, used in **Question 2**, is an aqueous solution of copper(II) sulfate.
FA 7 is solid sodium thiosulfate.
Carry out the following tests and record your observations in the table below.

	test	*observations*
(i)	Using a spatula, place 2 or 3 crystals of **FA 7** into a hard-glass test-tube. Heat gently for several seconds, then	
	heat strongly.	
(ii)	To a 1 cm depth of dilute sulfuric acid in a boiling tube, add a few crystals of **FA 7**. Observe until no further change occurs, then	
	warm the mixture, **gently and carefully**.	
(iii)	To a 1 cm depth of aqueous potassium iodide in a test-tube, add a few drops of **FA 6**, aqueous copper(II) sulfate, then	
	add **FA 1**, aqueous sodium thiosulfate, to the mixture until no further change occurs.	

(iv) Using your observations in **(ii)**, complete the equation below by giving the formulae of the other two products.

$$Na_2S_2O_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + \text{.....} + \text{.....}$$

[5]

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(b) **FA 8** and **FA 9** are aqueous solutions.
Each contains **one** cation and **one** anion from those listed on pages 14 and 15.
Carry out the tests and record all your observations in the table.
For each test, use a 1 cm depth of **FA 8** or **FA 9** in a test-tube.

test	*observations*	
	FA 8	**FA 9**
(i) Add aqueous sodium hydroxide.		
(ii) Add a few drops of aqueous silver nitrate followed by aqueous ammonia.		
(iii) Add aqueous ammonia.		
(iv) Add an equal depth of dilute sulfuric acid.		
(v) Add an equal depth of **FA 9**.		

(vi) Using your observations, identify **three** of the ions present in **FA 8** and **FA 9**.
Write 'unknown' next to the ion that you cannot identify directly from your observations.

ions in **FA 8**: cation ..... anion .....

ions in **FA 9**: cation ..... anion .....

(vii) The 'unknown' ion in **(vi)** can be identified by elimination, using the lists of ions on pages 14 and 15.
Choose **one** positive test that would confirm the identity of this ion. Name the reagent(s) you would use and state what you would observe if the test was positive.
Do not carry out this test.

'unknown' ion tested for .....

reagent(s) .....

observation(s) .....

[8]

[Total: 13]

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Qualitative Analysis Notes

Key: [ppt. = precipitate]

1 Reactions of aqueous cations

ion	*reaction with*	
	NaOH(aq)	NH_3(aq)
aluminium, Al^{3+}(aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH_4^+(aq)	no ppt. ammonia produced on heating	–
barium, Ba^{2+}(aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe^{2+}(aq)	green ppt. turning brown on contact with air insoluble in excess	green ppt. turning brown on contact with air insoluble in excess
iron(III), Fe^{3+}(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg^{2+}(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn^{2+}(aq)	off-white ppt. rapidly turning brown on contact with air insoluble in excess	off-white ppt. rapidly turning brown on contact with air insoluble in excess
zinc, Zn^{2+}(aq)	white ppt. soluble in excess	white ppt. soluble in excess

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2 Reactions of anions

ion	*reaction*
carbonate, CO_3^{2-}	CO_2 liberated by dilute acids
chloride, Cl^-(aq)	gives white ppt. with Ag^+(aq) (soluble in NH_3(aq))
bromide, Br^-(aq)	gives cream ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives yellow ppt. with Ag^+(aq) (insoluble in NH_3(aq))
nitrate, NO_3^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and Al foil; NO liberated by dilute acids (colourless NO → (pale) brown NO_2 in air)
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids)
sulfite, SO_3^{2-}(aq)	SO_2 liberated with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids)

3 Tests for gases

gas	*test and test result*
ammonia, NH_3	turns damp red litmus paper blue
carbon dioxide, CO_2	gives a white ppt. with limewater (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	“pops” with a lighted splint
oxygen, O_2	relights a glowing splint
sulfur dioxide, SO_2	turns acidified aqueous potassium manganate(VII) from purple to colourless

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