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## 9701/33

October/November 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 10 and 11.  
A Periodic Table is printed on page 12.

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.

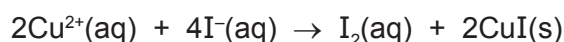
<b>Session</b>
<b>Laboratory</b>

For Examiner's Use	
1	
2	
3	
Total	

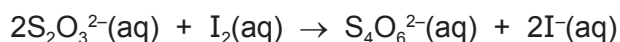
This document consists of **12** printed pages.

- 1 The formula of hydrated copper(II) sulfate is  $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$  where  $x$  is the number of moles of water of crystallisation in one mole of salt. You will determine the value of  $x$  by titration.

When aqueous copper(II) ions react with aqueous iodide ions,  $\text{I}^-$ , iodine is produced.



The amount of iodine,  $\text{I}_2$ , produced can be found by titrating it with aqueous thiosulfate ions,  $\text{S}_2\text{O}_3^{2-}$ .



**FA 1** is aqueous  $\text{CuSO}_4 \cdot x\text{H}_2\text{O}$  containing  $26.2 \text{ g dm}^{-3}$ .

**FA 2** is  $0.100 \text{ mol dm}^{-3}$  sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3$ .

**FA 3** is aqueous potassium iodide,  $\text{KI}$ .

starch indicator

### (a) Method

- Pipette  $25.0 \text{ cm}^3$  of **FA 1** into a conical flask.
- Use the measuring cylinder to add  $15 \text{ cm}^3$  of **FA 3**, an excess of  $\text{KI}$ , to the conical flask. The solution will turn brown because iodine is formed.
- Fill the burette with **FA 2**.
- Add **FA 2** from the burette until the colour of the mixture changes to pale brown.
- Add 10 drops of starch indicator. The mixture will turn blue-black.
- Continue adding **FA 2** from the burette until the dark colour suddenly disappears to leave an off-white solid. This is the end point of the titration.
- Carry out a rough titration and record your burette readings in the space below.

The rough titre is .....  $\text{cm}^3$ .

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make certain any recorded results show the precision of your practical work.
- Record in a suitable form below, all your burette readings and the volume of **FA 2** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

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

25.0 cm<sup>3</sup> of **FA 1** required ..... cm<sup>3</sup> of **FA 2**. [1]

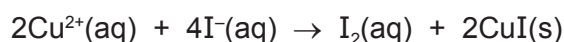
**(c) Calculations**

Show your working and appropriate significant figures in **each** step of your calculations.

- (i) Calculate the number of moles of thiosulfate ions present in the volume of **FA 2** you have calculated in (b).

moles of S<sub>2</sub>O<sub>3</sub><sup>2-</sup> = ..... mol

- (ii) Use your answer to (i), and the equations for the reactions involved, to deduce the number of moles of Cu<sup>2+</sup> present in 25.0 cm<sup>3</sup> of **FA 1**.



moles of Cu<sup>2+</sup> = ..... mol

- (iii) Use your answer to (ii) and the mass of CuSO<sub>4</sub>·xH<sub>2</sub>O present in the solution, to calculate the relative molecular mass, *M<sub>r</sub>*, of CuSO<sub>4</sub>·xH<sub>2</sub>O.

*M<sub>r</sub>* of CuSO<sub>4</sub>·xH<sub>2</sub>O = .....

- (iv) Determine the value of **x**.  
(Use data from the Periodic Table on page 12.)

**x** = .....  
[6]

[Total: 14]

- 2 **FA 4** is an impure sample of hydrated calcium chloride,  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ . On heating, hydrated calcium chloride loses its water of crystallisation.



You will determine the purity of **FA 4** by measuring the loss in mass that occurs when it is heated. The impurity present in **FA 4** is not decomposed on heating.

**(a) Method**

**You should read the instructions carefully before starting any practical work and draw a table for your results in the space below.**

- Weigh a crucible and record its mass.
- Add between 1.80 g and 2.00 g of **FA 4** into the crucible.
- Reweigh the crucible and its contents and record the mass.
- Place the crucible on the pipe-clay triangle and heat gently for 1 minute and then strongly for a further 2 minutes.
- Allow the crucible and its contents to cool. Reweigh the crucible and contents and record the mass.
- Heat the crucible strongly for a further 2 minutes. Allow it to cool. Reweigh the crucible and contents and record the mass.
- Repeat the heating, cooling and weighing until you are satisfied that all the water of crystallisation has been removed.
- Calculate and record the mass of **FA 4** used and the total mass of water lost.

**While you are waiting for the crucible to cool, you may wish to start work on Question 3.**

I	
II	
III	
IV	
V	
VI	

[6]

**(b) Calculations**

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

- (i) The percentage loss in mass on heating is defined as

$$\frac{\text{the loss in mass on heating}}{\text{the original mass}} \times 100.$$

Calculate the percentage loss in mass of **FA 4**.

percentage loss in mass = ..... %

- (ii) Calculate the percentage loss in mass when **pure** hydrated calcium chloride,  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ , is heated.

percentage loss in mass = ..... %

- (iii) Use your results to (i) and (ii) to calculate the percentage purity of **FA 4**, impure  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ .

percentage purity = ..... %  
[3]

- (c) A student carried out this experiment using 2.60 g of **FA 4**.

Suggest whether this experiment would give a more accurate result for the percentage purity of **FA 4**. Explain your answer.

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

- (d) In your calculations you assumed that the impurity in **FA 4** does not decompose on heating.

State how the percentage purity that you calculated in (b)(iii) would change if the impurity were to decompose on heating.

Explain your answer.

.....

..... [1]

[Total: 11]

### 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.**

**(a) (i) FA 5, FA 6 and FA 7** are aqueous solutions each containing one anion and one cation.

Carry out the experiments described below and record your observations for each solution in the table.

	<b>FA 5</b>	<b>FA 6</b>	<b>FA 7</b>
To a 1 cm depth in a test-tube, add a 1 cm depth of aqueous sodium carbonate.			
To a 1 cm depth in a test-tube, add a 1 cm depth of aqueous copper(II) sulfate.			
To a 1 cm depth in a test-tube, add a 1 cm depth of aqueous barium chloride or aqueous barium nitrate.			

**(ii)** What ion is present in **both FA 6 and FA 7**?

.....

**(iii)** The anion in **FA 5** is one of carbonate, chloride, nitrate or sulfate.

Which anion is present in **FA 5**?

.....

**(iv)** Write the ionic equation, including state symbols, for the reaction between **FA 5** and aqueous copper(II) sulfate.

.....

[7]

(b) **FA 8** contains two anions and two cations from the lists on pages 10 and 11.

- To a 5 cm depth of distilled water in a boiling tube, add all the **FA 8**.
- Shake the boiling tube thoroughly for one minute to make sure that no more of the solid will dissolve.
- Filter the mixture into a clean boiling tube.
- Place the filter funnel in a conical flask and wash the residue with a little distilled water.
- **Keep both filtrate and residue for tests (i) and (ii) below.**

(i) **Tests on the filtrate (the solution in the boiling tube)**

Carry out the following tests and record your observations in the table below.

<i>test</i>	<i>observations</i>
To a 1 cm depth of the filtrate in a test-tube, add aqueous sodium hydroxide, then	
add aqueous hydrogen peroxide.	

(ii) **Tests on the residue**

Carry out the following tests and record your observations in the table below.

<i>test</i>	<i>observations</i>
Place the funnel containing the residue into a clean boiling tube. Pour approximately 5 cm <sup>3</sup> of dilute nitric acid onto the residue. Collect a 1 cm depth of solution in the boiling tube. Remove the funnel and return it to the conical flask.	
To this solution in the boiling tube, add aqueous sodium hydroxide.	



(iii) Identify **two** cations present in **FA 8**.

cations present ..... and .....

(iv) Identify **one** anion present in **FA 8**.

anion present .....

(v) Suggest what type of reaction is happening when hydrogen peroxide is added in test (b)(i).

.....  
[8]

[Total: 15]

## Qualitative Analysis Notes

Key: [ppt. = precipitate]

## 1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH <sub>3</sub> (aq)
aluminium, Al <sup>3+</sup> (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH <sub>4</sub> <sup>+</sup> (aq)	no ppt. ammonia produced on heating	—
barium, Ba <sup>2+</sup> (aq)	no ppt. (if reagents are pure)	no ppt.
calcium, Ca <sup>2+</sup> (aq)	white ppt. with high [Ca <sup>2+</sup> (aq)]	no ppt.
chromium(III), Cr <sup>3+</sup> (aq)	grey-green ppt. soluble in excess giving dark green solution	grey-green ppt. insoluble in excess
copper(II), Cu <sup>2+</sup> (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe <sup>2+</sup> (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 <sup>3+</sup> (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg <sup>2+</sup> (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn <sup>2+</sup> (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 <sup>2+</sup> (aq)	white ppt. soluble in excess	white ppt. soluble in excess

## 2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, $\text{CO}_3^{2-}$	$\text{CO}_2$ liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$ )
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$ )
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$ )
nitrate, $\text{NO}_3^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil
nitrite, $\text{NO}_2^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil; $\text{NO}$ liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown $\text{NO}_2$ in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	$\text{SO}_2$ liberated with dilute acids; gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)

## 3 Tests for gases

<i>gas</i>	<i>test and test result</i>
ammonia, $\text{NH}_3$	turns damp red litmus paper blue
carbon dioxide, $\text{CO}_2$	gives a white ppt. with limewater (ppt. dissolves with excess $\text{CO}_2$ )
chlorine, $\text{Cl}_2$	bleaches damp litmus paper
hydrogen, $\text{H}_2$	“pops” with a lighted splint
oxygen, $\text{O}_2$	relights a glowing splint
sulfur dioxide, $\text{SO}_2$	turns acidified aqueous potassium manganate(VII) from purple to colourless

## The Periodic Table of the Elements

Group																			
I	II											III	IV	V	VI	VII	0		
												1.0 <b>H</b> Hydrogen 1							
6.9 <b>Li</b> Lithium 3	9.0 <b>Be</b> Beryllium 4																		
23.0 <b>Na</b> Sodium 11	24.3 <b>Mg</b> Magnesium 12											10.8 <b>B</b> Boron 5	12.0 <b>C</b> Carbon 6	14.0 <b>N</b> Nitrogen 7	16.0 <b>O</b> Oxygen 8	19.0 <b>F</b> Fluorine 9	20.2 <b>Ne</b> Neon 10		
												27.0 <b>Al</b> Aluminium 13	28.1 <b>Si</b> Silicon 14	31.0 <b>P</b> Phosphorus 15	32.1 <b>S</b> Sulfur 16	35.5 <b>Cl</b> Chlorine 17	39.9 <b>Ar</b> Argon 18		
39.1 <b>K</b> Potassium 19	40.1 <b>Ca</b> Calcium 20	45.0 <b>Sc</b> Scandium 21	47.9 <b>Ti</b> Titanium 22	50.9 <b>V</b> Vanadium 23	52.0 <b>Cr</b> Chromium 24	54.9 <b>Mn</b> Manganese 25	55.8 <b>Fe</b> Iron 26	58.9 <b>Co</b> Cobalt 27	58.7 <b>Ni</b> Nickel 28	63.5 <b>Cu</b> Copper 29	65.4 <b>Zn</b> Zinc 30	69.7 <b>Ga</b> Gallium 31	72.6 <b>Ge</b> Germanium 32	74.9 <b>As</b> Arsenic 33	79.0 <b>Se</b> Selenium 34	79.9 <b>Br</b> Bromine 35	83.8 <b>Kr</b> Krypton 36		
85.5 <b>Rb</b> Rubidium 37	87.6 <b>Sr</b> Strontium 38	88.9 <b>Y</b> Yttrium 39	91.2 <b>Zr</b> Zirconium 40	92.9 <b>Nb</b> Niobium 41	95.9 <b>Mo</b> Molybdenum 42	98.9 <b>Tc</b> Technetium 43	101 <b>Ru</b> Ruthenium 44	103 <b>Rh</b> Rhodium 45	106 <b>Pd</b> Palladium 46	108 <b>Ag</b> Silver 47	112 <b>Cd</b> Cadmium 48	115 <b>In</b> Indium 49	119 <b>Sn</b> Tin 50	122 <b>Sb</b> Antimony 51	128 <b>Te</b> Tellurium 52	127 <b>I</b> Iodine 53	131 <b>Xe</b> Xenon 54		
133 <b>Cs</b> Caesium 55	137 <b>Ba</b> Barium 56	139 <b>La</b> Lanthanum 57	178 <b>Hf</b> Hafnium 72	181 <b>Ta</b> Tantalum 73	184 <b>W</b> Tungsten 74	186 <b>Re</b> Rhenium 75	190 <b>Os</b> Osmium 76	192 <b>Ir</b> Iridium 77	195 <b>Pt</b> Platinum 78	197 <b>Au</b> Gold 79	201 <b>Hg</b> Mercury 80	204 <b>Tl</b> Thallium 81	207 <b>Pb</b> Lead 82	209 <b>Bi</b> Bismuth 83	210 <b>Po</b> Polonium 84	210 <b>At</b> Astatine 85	222 <b>Rn</b> Radon 86		
223 <b>Fr</b> Francium 87	226 <b>Ra</b> Radium 88	227 <b>Ac</b> Actinium 89	227 <b>Rf</b> Rutherfordium 104	261 <b>Db</b> Dubnium 105	263 <b>Sg</b> Seaborgium 106	264 <b>Bh</b> Bohrium 107	269 <b>Hs</b> Hassium 108	278 <b>Mt</b> Meitnerium 109	288 <b>Un</b> Ununnilium 110	289 <b>Uuu</b> Unununnium 111	289 <b>Uub</b> Ununbium 112	289 <b>Uuq</b> Ununquadium 114	289 <b>Uuh</b> Ununhexium 116	289 <b>Uuo</b> Ununoctium 118					

\*58-71 Lanthanides  
90-103 Actinides

\*

**Key**

a	<b>X</b>
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a = relative atomic mass      †  
X = atomic symbol  
b = proton (atomic) number

140	Ce Cerium	141	Pr Praseodymium	144	Nd Neodymium	150	Sm Samarium	152	Eu Europium	157	Gd Gadolinium	159	Tb Terbium	163	Dy Dysprosium	165	Ho Holmium	167	Er Erbium	169	Tm Thulium	173	Yb Ytterbium	175	Lu Lutetium		
58		59		60		61	Pm	63	Eu	64	Gd	65	Tb	66	Dy	67	Ho	68	Er	69	Tm	70	Yb	71	Lu		
90	Th Thorium	91	Pa Protactinium	92	U Uranium	93	Np Neptunium	94	Pu Plutonium	95	Am Americium	96	Cm Curium	97	Bk Berkelium	98	Cf Californium	99	Es Einsteinium	100	Fm Fermium	101	Md Mendelevium	102	No Nobelium	103	Lr Lawrencium

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