

Cambridge
International
AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

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CHEMISTRY

9701/33

Paper 3 Advanced Practical Skills 1

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.

| | |
|-------------------|--|
| Session | |
| | |
| Laboratory | |
| | |

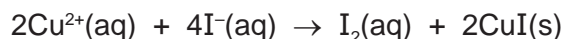
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| For Examiner's Use | |
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| Total | |

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

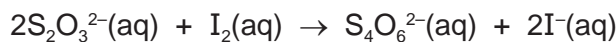
2

- 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, I^- , iodine is produced.



The amount of iodine, 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 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, KI .

starch indicator

(a) Method

- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Use the measuring cylinder to add 15 cm^3 of **FA 3**, an excess of 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 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 cm³ of **FA 1** required cm³ of **FA 2**. [1]

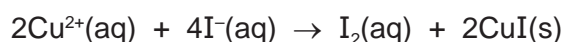
(c) Calculations

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 S₂O₃²⁻ = mol

- (ii) Use your answer to (i), and the equations for the reactions involved, to deduce the number of moles of Cu²⁺ present in 25.0 cm³ of **FA 1**.



moles of Cu²⁺ = mol

- (iii) Use your answer to (ii) and the mass of CuSO₄·xH₂O present in the solution, to calculate the relative molecular mass, M_r, of CuSO₄·xH₂O.

M_r of CuSO₄·xH₂O =

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

x =
[6]

[Total: 14]

4

- 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]

6

(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.

| | FA 5 | FA 6 | FA 7 |
|--|------|------|------|
| 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 ³ 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 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 |

2 Reactions of anions

| <i>ion</i> | <i>reaction</i> |
|---|---|
| carbonate, CO_3^{2-} | 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, $\text{NO}_3^-(\text{aq})$ | NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil |
| nitrite, $\text{NO}_2^-(\text{aq})$ | NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil; NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown 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, $\text{SO}_3^{2-}(\text{aq})$ | 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, 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 |

The Periodic Table of the Elements

| | | Group | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|-------------------------------------|------------------------------------|------------------------------------|--|--------------------------------------|--------------------------------------|------------------------------------|------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|------------------------------------|-------------------------------------|------------------------------------|--|--------------------------------------|--------------------------------------|------------------------------------|---------------------------------------|-------------------------------------|-----------------------------------|-------------------------------------|----------------------------------|-----------------------------------|------------------------------------|------------------------------------|------------------------------------|------------------------------------|----------------------------------|------------------------------------|-----------------------------------|--|----------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|----------------------------------|-------------------------------------|---------------------------------------|---------------------------------------|------------------------------------|--|-------------------------------------|---------------------------------------|
| I | II | III | IV | V | VI | VII | 0 | | | | | 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6.9 Li Lithium 3 | 9.0 Be Beryllium 4 | 1.0 H Hydrogen 1 | 10.8 B Boron 5 | 12.0 C Carbon 6 | 14.0 N Nitrogen 7 | 16.0 O Oxygen 8 | 19.0 F Fluorine 9 | 20.2 Ne Neon 10 | 27.0 Al Aluminium 13 | 28.1 Si Silicon 14 | 31.0 P Phosphorus 15 | 32.1 S Sulfur 16 | 35.5 Cl Chlorine 17 | 39.9 Ar Argon 18 | 40 He Helium 2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 39.1 K Potassium 19 | 40.1 Ca Calcium 20 | 50.9 V Vanadium 23 | 52.0 Cr Chromium 24 | 54.9 Mn Manganese 25 | 55.8 Fe Iron 26 | 58.9 Co Cobalt 27 | 58.7 Ni Nickel 28 | 63.5 Cu Copper 29 | 65.4 Zn Zinc 30 | 69.7 Ga Gallium 31 | 72.6 Ge Germanium 32 | 74.9 As Arsenic 33 | 79.9 Br Bromine 35 | 83.8 Kr Krypton 36 | 85.5 Rb Rubidium 37 | 87.6 Sr Strontium 38 | 91.2 Zr Zirconium 40 | 92.9 Nb Niobium 41 | 95.9 Mo Molybdenum 42 | 101 Ru Ruthenium 44 | 103 Rh Rhodium 45 | 106 Pd Palladium 46 | 108 Ag Silver 47 | 112 Cd Cadmium 48 | 115 In Indium 49 | 119 Sn Tin 50 | 122 Sb Antimony 51 | 127 I Iodine 53 | 131 Xe Xenon 54 | | | | | | | | | | | | | | | |
| 133 Cs Caesium 55 | 137 Ba Barium 56 | 140 Ce Cerium 58 | 141 Pr Praseodymium 59 | 144 Nd Neodymium 60 | 147 Pm Promethium 61 | 150 Sm Samarium 62 | 152 Eu Europium 63 | 157 Gd Gadolinium 64 | 159 Tb Terbium 65 | 163 Dy Dysprosium 66 | 165 Ho Holmium 67 | 167 Er Erbium 68 | 173 Yb Ytterbium 70 | 175 Lu Lutetium 71 | 187 Rf Rutherfordium 104 | 188 Re Rhenium 75 | 186 Os Osmium 76 | 192 Ir Iridium 77 | 195 Pt Platinum 78 | 197 Au Gold 79 | 201 Hg Mercury 80 | 204 Tl Thallium 81 | 207 Pb Lead 82 | 209 Bi Bismuth 83 | 210 Po Polonium 84 | 210 At Astatine 85 | 210 Rn Radon 86 | 223 Fr Francium 87 | 226 Ra Radium 88 | 227 Ac Actinium 89 | 232 Th Thorium 90 | 231 Pa Protactinium 91 | 238 U Uranium 92 | 238 Np Neptunium 93 | 244 Pu Plutonium 94 | 247 Am Americium 95 | 251 Cm Curium 96 | 252 Bk Berkelium 97 | 257 Cf Californium 98 | 259 Es Einsteinium 99 | 265 Fm Fermium 100 | 269 Md Mendelevium 101 | 270 No Nobelium 102 | 285 Lr Lawrencium 103 |

*58-71 Lanthanides
†90-103 Actinides

Key

| | |
|---|---|
| a | X |
| b | |

 a = relative atomic mass
 X = atomic symbol
 b = proton (atomic) number

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