



UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS  
General Certificate of Education Advanced Subsidiary Level and Advanced Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER



**CHEMISTRY**

**9701/32**

Paper 32 Practical Test

**May/June 2007**

**2 hours**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Instructions to Supervisors

**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 a soft pencil for any diagrams, graphs or rough working.  
Do not use staples, paper clips, highlighters, glue or correction fluid.  
**DO NOT WRITE IN ANY BARCODES.**

Answer **all** questions.  
You are advised to show all working in calculations.  
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 11 and 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>         |  |
|                           |  |
| <b>For Examiner's Use</b> |  |
| 1                         |  |
| 2                         |  |
| 3                         |  |
| <b>Total</b>              |  |

This document consists of **11** printed pages and **1** blank page.

- 1 You are required to determine the concentration in  $\text{g dm}^{-3}$  of hydrated ammonium iron(II) sulphate,  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot 6\text{H}_2\text{O}$ , in the solution **FB 1**.

**FB 1** contains hydrated ammonium iron(II) sulphate.

**FB 2** is  $0.0120 \text{ mol dm}^{-3}$  potassium manganate(VII),  $\text{KMnO}_4$ .

**(a) Dilution of FB 1**

By using a burette measure between  $36.00 \text{ cm}^3$  and  $37.00 \text{ cm}^3$  of **FB 1** into the  $250 \text{ cm}^3$  graduated flask labelled **FB 3**.

Record your burette readings and the volume of **FB 1** added to the flask in the space below.

Make up the contents of the flask to the  $250 \text{ cm}^3$  mark with distilled water. Place the stopper in the flask and mix the contents thoroughly by slowly inverting the flask a number of times.

**Titration**

Fill a second burette with **FB 2**.

Pipette  $25.0 \text{ cm}^3$  of **FB 3** into a conical flask. Use a measuring cylinder to add approximately  $10 \text{ cm}^3$  of  $1.0 \text{ mol dm}^{-3}$  sulphuric acid,  $\text{H}_2\text{SO}_4$ , and titrate with **FB 2** until the first permanent pink colour remains in the solution.

**Perform one rough (trial) titration and sufficient further titrations to obtain accurate results.**

Record your titration results in the space below. Make certain that your recorded results show the precision of your working.

|     |  |
|-----|--|
| i   |  |
| ii  |  |
| iii |  |
| iv  |  |
| v   |  |
| vi  |  |

[6]

- (b) From your titration results obtain a suitable volume of **FB 2** to be used in your calculations.  
Show clearly how you obtained this volume.

[1]

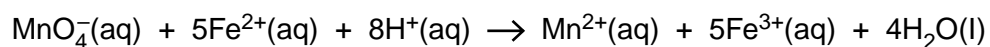
**Calculations**

Show your working and appropriate significant figures in all of your calculations.

- (c) Calculate how many moles of  $\text{KMnO}_4$  were run from the burette during the titration.

..... mol of  $\text{KMnO}_4$  were run from the burette.

Calculate how many moles of  $\text{Fe}^{2+}$  ions reacted with the  $\text{KMnO}_4$  run from the burette.



..... mol of  $\text{Fe}^{2+}$  reacted with the  $\text{KMnO}_4$  run from the burette.

Calculate the concentration, in  $\text{mol dm}^{-3}$ , of  $\text{Fe}^{2+}$  in **FB 3**.

Concentration of  $\text{Fe}^{2+}$  in **FB 3** = .....  $\text{mol dm}^{-3}$ .

Calculate the concentration, in  $\text{mol dm}^{-3}$ , of  $\text{Fe}^{2+}$  in **FB 1**.

Concentration of  $\text{Fe}^{2+}$  in **FB 1** = .....  $\text{mol dm}^{-3}$ .

Calculate, to **4 significant figures**, the concentration of  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot 6\text{H}_2\text{O}$  in **FB 1** in  $\text{g dm}^{-3}$ .

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

**FB 1** contains .....  $\text{g dm}^{-3}$  of  $(\text{NH}_4)_2\text{SO}_4 \cdot \text{FeSO}_4 \cdot 6\text{H}_2\text{O}$ .  
[5]

- (d) A student learns that the solution of the iron(II) salt has been prepared by dissolving the solid in distilled water that has absorbed air from the laboratory. Suggest a way in which the distilled water can be prepared and stored in the laboratory to ensure that it contains a minimum of dissolved air.

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

- (e) Estimate the error in reading a volume from a burette.

smallest division on burette scale = .....  $\text{cm}^3$

estimated error in reading a volume =  $\pm$  .....  $\text{cm}^3$  [1]

- (f) A titre value is obtained by the difference between final and initial burette readings.

What is the **maximum** possible error in obtaining a titre reading?

estimated **maximum** error in the titre =  $\pm$  .....  $\text{cm}^3$  [1]

- (g) During one titration a student reads the burette twice.

Each reading has an error but the titre has no error. Explain how this can happen.

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

[Total: 16]

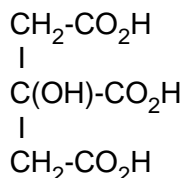
|     |  |
|-----|--|
| i   |  |
| ii  |  |
| iii |  |
| iv  |  |
| v   |  |



- 2 Read through the question before starting any practical work.

You are required to determine the enthalpy change when citric acid reacts with an excess of sodium hydrogencarbonate.

Citric acid, found in citrus fruit such as lemons and limes, is 2-hydroxypropane-1,2,3-tricarboxylic acid.



**FB 4** is  $0.8 \text{ mol dm}^{-3}$  citric acid.

**FB 5** is solid sodium hydrogencarbonate,  $\text{NaHCO}_3$ .

- (a) Citric acid is a triprotic (tribasic) acid – one mole of the acid reacts with three moles of sodium hydrogencarbonate.

Calculate the minimum mass of sodium hydrogencarbonate that will react with all of the acid in  $50.0 \text{ cm}^3$  of **FB 4**.

[ $A_r$ : Na, 23.0; H, 1.0; C, 12.0; O, 16.0]

mass of  $\text{NaHCO}_3 = \dots\dots\dots \text{ g [1]}$

**(b) Method**

Follow the instructions below to determine the enthalpy change for the reaction. You will carry out the experiment twice.

- Weigh the empty weighing bottle.
- Weigh the bottle with between 11.5 g and 12.0 g, an excess, of **FB 5**.
- Support the plastic cup in the  $250 \text{ cm}^3$  beaker and pipette into it  $50.0 \text{ cm}^3$  of **FB 4**.
- Measure and record the steady temperature of the **FB 4** in the plastic cup.
- Add the **FB 5** from the weighing bottle, a little at a time, to the plastic cup.
- Stir and record the lowest temperature reached.
- Reweigh the empty weighing bottle.

In an appropriate form at the top of the next page record

- all measurements of mass and temperature,
- the temperature fall,  $\Delta T$ .

Empty and rinse the plastic cup.

Repeat the experiment and calculate the mean value of  $\Delta T$ .

**Results**

The mean value of  $\Delta T$  is ..... °C.

[6]

- (c) Calculate the enthalpy change of reaction using the following expression.

$$\Delta H_{\text{reaction}} = \text{mean } \Delta T \times 4.3 \text{ kJ mol}^{-1}$$

Your answer should include the appropriate sign.

$$\Delta H_{\text{reaction}} = \dots\dots\dots \text{ kJ mol}^{-1} \text{ [1]}$$

[Total: 8]

- 3 You are provided with three solutions, **FB 6**, **FB 7** and **FB 8**, each containing one cation and one anion.

One or more of the solutions contains a halide ion. One or more of the solutions contains a sulphate or sulphite ion.

**Identification of the anions in FB 6, FB 7 and FB 8**

- (a) By reference to the Qualitative Analysis Notes on page 12 you are to select and use
- (i) one reagent to precipitate any halide ion that is present,
  - (ii) a second reagent to confirm the identity of any halide ion present.

Because the solutions are coloured you will need to remove traces of solution from the precipitates.

Record the tests performed, the practical procedures used and the observations made for each of the solutions.

Present this information as clearly as possible in a suitable format in the space below.

|     |  |
|-----|--|
| i   |  |
| ii  |  |
| iii |  |
| iv  |  |
| v   |  |
| vi  |  |
| vii |  |

Use your observations to identify any halide ions present in the solutions **FB 6**, **FB 7** and **FB 8** and state which ion is present in which solution.

.....

.....

.....

.....

.....



**(b)** Select reagents and carry out tests

- (i)** to show which of the solutions contains a sulphate ion or a sulphite ion, and
- (ii)** to establish which of these ions is present.

Record your tests and observations below.

State which of the ions, sulphate or sulphite, is present in which of the solutions **FB 6**, **FB 7** and **FB 8** and explain how you reached this conclusion from your tests above.

.....

.....

.....

[3]

**Identification of the cations in FB 6, FB 7 and FB 8**

- (c)** Using aqueous sodium hydroxide and aqueous ammonia it is possible to identify two of the cations present and to draw some conclusions about the nature of the remaining cation.

Carry out tests with these reagents, recording details of what you did and observed in a suitable format in the space below.

[4]

(d) Explain how your observations in (c) identify **two** of the cations present and which of the solutions contain those cations.

The cation contained in solution **FB** ..... is .....

explanation

.....  
.....  
.....

The cation contained in solution **FB** ..... is .....

explanation

.....  
.....  
.....

What conclusion of a general nature about the third cation can you draw from your observations in (c)?

.....  
.....  
.....  
.....  
.....  
.....

[2]

[Total: 16]

Key: [ppt. = precipitate.]

## 1 Reactions of aqueous cations

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

[Lead(II) ions can be distinguished from aluminium ions by the insolubility of lead(II) chloride.]

## 2 Reactions of anions

| <i>ion</i>                                | <i>reaction</i>   |
|---|---|
| carbonate,<br>$\text{CO}_3^{2-}$          | $\text{CO}_2$ liberated by dilute acids   |
| chromate(VI),<br>$\text{CrO}_4^{2-}$ (aq) | yellow solution turns orange with $\text{H}^+(\text{aq})$ ;<br>gives yellow ppt. with $\text{Ba}^{2+}(\text{aq})$ ;<br>gives bright yellow ppt. with $\text{Pb}^{2+}(\text{aq})$                        |
| chloride,<br>$\text{Cl}^-$ (aq)           | gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$ );<br>gives white ppt. with $\text{Pb}^{2+}(\text{aq})$   |
| bromide,<br>$\text{Br}^-$ (aq)            | gives pale cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$ );<br>gives white ppt. with $\text{Pb}^{2+}(\text{aq})$  |
| iodide,<br>$\text{I}^-$ (aq)              | gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$ );<br>gives yellow ppt. with $\text{Pb}^{2+}(\text{aq})$   |
| nitrate,<br>$\text{NO}_3^-$ (aq)          | $\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and <i>Al</i> foil   |
| nitrite,<br>$\text{NO}_2^-$ (aq)          | $\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and <i>Al</i> foil,<br>$\text{NO}$ liberated by dilute acids<br>(colourless $\text{NO} \rightarrow$ (pale) brown $\text{NO}_2$ in air) |
| sulphate,<br>$\text{SO}_4^{2-}$ (aq)      | gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ or with $\text{Pb}^{2+}(\text{aq})$ (insoluble in excess dilute strong acid)  |
| sulphite,<br>$\text{SO}_3^{2-}$ (aq)      | $\text{SO}_2$ liberated with dilute acids;<br>gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acid)  |

## 3 Tests for gases

| <i>gas</i>                     | <i>test and test results</i>   |
|--------------------------------|--|
| ammonia, $\text{NH}_3$         | turns damp red litmus paper blue   |
| carbon dioxide, $\text{CO}_2$  | gives a white ppt. with limewater<br>(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  |
| sulphur dioxide, $\text{SO}_2$ | turns potassium dichromate(VI) (aq) from orange to green                         |

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