Cambridge Pre-U

UNIVERSITY OF CAMBRIDGE INTERNATIONAL EXAMINATIONS
Cambridge International Level 3 Pre-U Certificate
Principal Subject

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER



**CHEMISTRY** **9791/04**

Paper 4 Practical **May/June 2013**

**2 hours**

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions
Data Booklet

**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.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
A Data Booklet is provided.

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 **11** printed pages and **1** blank page.

**1** In this experiment you will determine the relative proportions of sodium carbonate and sodium hydrogencarbonate in a mixture. You will first make up a solution from a mixture of the salts and then titrate this solution using hydrochloric acid.

*For Examiner's Use*

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

$$HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$$

The following reagents are provided.

**FA 1** is a mixture of anhydrous sodium carbonate, $Na_2CO_3$, and sodium hydrogencarbonate, $NaHCO_3$.

**FA 2** is 0.200 mol $dm^{-3}$ hydrochloric acid, HC*l*.

methyl orange indicator

**(a) Method**

**Before starting any practical work, read through all the instructions and prepare suitable tables for your results in the spaces provided.**

**Preparing the solution**

1. Weigh the weighing bottle containing **FA 1**.
2. Tip the contents of the weighing bottle into a 250 $cm^3$ beaker.
3. Reweigh the weighing bottle.
4. Add approximately 150 $cm^3$ of distilled water to the beaker and stir until the mixture of salts has dissolved.
5. Transfer the contents carefully into the 250 $cm^3$ volumetric flask.
6. Rinse the beaker with a little distilled water and add these washings to the volumetric flask.
7. Fill the volumetric flask to the line with distilled water. Stopper the flask and invert several times to ensure thorough mixing.

Record in the space below both weighings and the mass of **FA 1** added.

**Titration**

*For Examiner's Use*

8. Fill a burette with the hydrochloric acid, **FA 2**.
9. Use a pipette to transfer 25.00 $cm^3$ of the solution from the volumetric flask into a conical flask.
10. Add 5 drops of methyl orange indicator to the conical flask.
11. Titrate the solution in the conical flask with **FA 2**.
12. Repeat the titration as many times as you feel are necessary to obtain consistent results.
13. Record your results in a suitable form in the space below.

| | |
|---|---|
| I | |
| II | |
| III | |
| IV | |
| V | |
| VI | |
| VII | |
| VIII | |

[8]

**(b)** From your titration results obtain a volume of **FA 2** to be used in the following calculations. Show clearly how you obtained this value.

25.00 $cm^3$ of the solution of **FA 1** required …… $cm^3$ of **FA 2**.

[2]

**(c)** By performing the following calculations you will determine the mass of sodium hydrogencarbonate present in **FA 1**.

*For Examiner's Use*

**You must show your working.**

**(i)** Calculate the amount, in mol, of hydrochloric acid present in the volume of **FA 2** calculated in **(b)**.

..... mol

**(ii)** Calculate the amount, in mol, of hydrochloric acid that would have reacted with the total mass of **FA 1**.

..... mol

**(iii)** Use your answer to **(c)(ii)** and the following expression to calculate the mass of sodium hydrogencarbonate in **FA 1**.

$$2\left(\frac{M - m}{106}\right) + \frac{m}{84} = \text{answer to } \textbf{(c)(ii)}$$

where
M = the mass of **FA 1**
m = the mass of sodium hydrogencarbonate

| | |
|---|---|
| I | |
| II | |
| III | |

the mass of sodium hydrogencarbonate in **FA 1** = ..... g
[3]

[Total: 13]

**Question 2 begins on page 6.**

**2** Another way to analyse a mixture of sodium carbonate and sodium hydrogencarbonate is to measure the temperature change that occurs when a known mass of the mixture is added to acid.

*For Examiner's Use*

**FA 3** is a mixture of anhydrous sodium carbonate, $Na_2CO_3$, and sodium hydrogencarbonate, $NaHCO_3$. This mixture is **not** the same as **FA 1**.

**FA 4** is 2.00 mol $dm^{-3}$ hydrochloric acid, HC*l*.

**(a) Method**

**Before starting any practical work, read through all the instructions and prepare a suitable table for your results in the space provided.**

1. Support a plastic cup in a 250 $cm^3$ beaker.
2. Using a 25 $cm^3$ measuring cylinder, pour 25 $cm^3$ of **FA 4**, the hydrochloric acid, into the plastic cup.
3. Measure the temperature of the acid in the cup.
4. Weigh the bottle containing **FA 3**.
5. Add the contents of the bottle to the acid in a number of portions to avoid acid spray.
6. Use the thermometer to stir the mixture gently.
7. Measure the temperature that is reached.
8. Reweigh the bottle.

Record all the measurements from your experiment. Include the mass of **FA 3**, *M*, added to the acid and the change in temperature, $\Delta T$, where $\Delta T$ = final temperature – initial temperature.

| | |
|---|---|
| I | |
| II | |
| III | |
| IV | |

[4]

**(b)** In the following calculations you will work out the percentage by mass of sodium hydrogencarbonate in **FA 3**.

*For Examiner's Use*

**You must show your working.**

**(i)** Calculate the change in temperature for each gram of **FA 3** added to the acid.

$$\frac{\Delta T}{M} = \underset{sign}{\ldots\ldots\ldots} \quad \ldots\ldots\ldots\ldots\ldots\ldots °C\,g^{-1}$$

**(ii)** A student carried out similar experiments using separate samples of the two salts.

For pure sodium carbonate the change in temperature per gram was $+3.38\,°C\,g^{-1}$.

For pure sodium hydrogencarbonate the change in temperature per gram was $-2.74\,°C\,g^{-1}$.

Use these values and your answer to **(b)(i)** to calculate the mass and the percentage by mass of sodium hydrogencarbonate in **FA 3**.

If your answer to **(b)(i)** does **not** lie between +3.38 and $-2.74\,°C\,g^{-1}$ then assume that the answer to **(b)(i)** is $+1.36\,°C\,g^{-1}$. This is not the correct value.

| | |
|---|---|
| I | |
| II | |
| III | |
| IV | |
| V | |

mass of sodium hydrogencarbonate = ..... g

percentage by mass of sodium hydrogencarbonate = ..... %
[5]

**(c)** **(i)** State the uncertainty in the measurement of **each** mass in this experiment.

uncertainty = ± ..... g

**(ii)** Calculate the percentage error in the mass of **FA 3** that was used.

percentage error = ..... %
[1]



**[Turn over**

**(d)** The experiment was repeated using the **same** apparatus but this time twice the mass of **FA 3** was added to 50 $cm^3$ of the hydrochloric acid.

*For Examiner's Use*

Discuss whether this would determine more accurately the percentage of sodium hydrogencarbonate in **FA 3**.

.....

.....

.....

.....[2]

[Total: 12]

**Question 3 begins on page 10.**

**3 (a)** **FA 5, FA 6** and **FA 7** are different salts, each of which is one of the following.

*For Examiner's Use*

a hydrated metal carbonate
a hydrated metal chloride
a metal nitrate

By heating each of the solids and analysing the gases given off, you will be able to assign the identities of the different salts.

In this case the metal nitrate undergoes thermal decomposition to give the metal nitrite as well as the gaseous product.

For each solid, place a small spatula measure into hard-glass test-tube and heat strongly. Record your observations in the following table. Describe the positive tests you carried out on the gases released and suggest the identity of each gas.

| | *observations* | *gas test and identity of gas* |
|---|---|---|
| **FA 5** | | |
| **FA 6** | | |
| **FA 7** | | |

| | |
|---|---|
| I | |
| II | |
| III | |
| IV | |
| V | |
| VI | |
| VII | |
| VIII | |
| IX | |

From your observations assign **FA 5**, **FA 6** and **FA 7**.

*For Examiner's Use*

The hydrated metal carbonate is …… .

The hydrated metal chloride is …… .

The metal nitrate is …… .

[9]

**(b)** **FA 8** is a solution that contains two different anions.

**(i)** Carry out the following tests and record your observations in the space below. Keep the contents of each test-tube for a further test in **(ii)**.

| *test* | *observations* |
|---|---|
| To a 1 cm depth of **FA 8** in a test-tube add 1 cm depth of aqueous barium chloride (or aqueous barium nitrate). | |
| To a 1 cm depth of **FA 8** in a second test-tube add 1 cm depth of dilute nitric acid followed by a 1 cm depth of aqueous silver nitrate. | |

**(ii)** Carry out two additional tests, one on the contents of each test-tube, to identify the anions present in **FA 8**.

test one .....

.....

observation .....

test two .....

.....

observation.....

The anions in **FA 8** are …… and …… .

[6]

[Total: 15]

| | |
|---|---|
| I | |
| II | |
| III | |
| IV | |
| V | |
| VI | |

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