Cambridge International AS & A Level

**Cambridge Assessment International Education**
Cambridge International Advanced Subsidiary and Advanced Level

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| CANDIDATE NAME | |

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| CENTRE NUMBER | | | | | | CANDIDATE NUMBER | | | | | |

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**CHEMISTRY** **9701/35**

Paper 3 Advanced Practical Skills 1 **May/June 2019**

**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 copy of the 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** |
| |

| **For Examiner's Use** | |
|---|---|
| **1** | |
| **2** | |
| **3** | |
| **Total** | |

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

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Cambridge Assessment International Education

**Quantitative Analysis**

Read through the whole method before starting any practical work. Where appropriate, prepare a table for your results in the space provided.

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

**1** The reaction between acids and alkalis is exothermic. You will find the concentration of a monoprotic acid, HZ, by a thermometric method using a solution of sodium hydroxide of known concentration.

$$HZ(aq) + NaOH(aq) \rightarrow NaZ(aq) + H_2O(l)$$

**FA 1** is a solution of acid HZ.
**FA 2** is 2.00 mol dm$^{-3}$ sodium hydroxide, NaOH.

**(a) Method**

- Place the thermometer into **FA 1**. Record the temperature of **FA 1** in the table. This is the temperature when the volume of **FA 2** is 0.0.
- Rinse and dry the thermometer.
- Place the thermometer into **FA 2**. Record the temperature of **FA 2** in the table. This is the temperature when the volume of **FA 1** is 0.0.

- Fill a burette with **FA 1**.
- Support the plastic cup in the 250 cm$^3$ beaker.
- From the burette transfer 35.0 cm$^3$ of **FA 1** into the plastic cup.
- Use the 50 cm$^3$ measuring cylinder to measure 5.0 cm$^3$ of **FA 2**.
- Transfer the 5.0 cm$^3$ of **FA 2** into the plastic cup. Stir the mixture and record the highest temperature.
- Tip out the solution, rinse the plastic cup with water, shake it to remove excess water and replace the cup in the beaker.
- Rinse and dry the thermometer.

- Use the burette to transfer 30.0 cm$^3$ of **FA 1** into the plastic cup.
- Use the measuring cylinder to transfer 10.0 cm$^3$ of **FA 2** into the plastic cup.
- Stir the mixture and record the highest temperature.
- Tip out the solution, rinse the plastic cup with water, shake it to remove excess water and replace the cup in the beaker.
- Rinse and dry the thermometer.

- Continue the experiment using the volumes of **FA 1** and **FA 2** given in the table and record the maximum temperature of each mixture.

| volume **FA 1** / cm$^3$ | 40.0 | 35.0 | 30.0 | 25.0 | 20.0 | 15.0 | 10.0 | 5.0 | 0.0 |
|---|---|---|---|---|---|---|---|---|---|
| volume **FA 2** / cm$^3$ | 0.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
| temperature / °C | | | | | | | | | |

[3]

**Keep FA 1 for use in Question 2.**

**(b) (i)** Plot a graph of temperature of solution (*y*-axis) against volume of **FA 2** added (*x*-axis) on the grid. Select a scale on the *y*-axis to include a temperature of 2 °C above your maximum thermometer reading. Label any points you consider anomalous.

Draw two lines of best fit through the points on your graph, the first for the increase in temperature and the second for the decrease in temperature of the mixtures. Extrapolate the two lines so they intersect. [3]

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

 

**(ii)** The intersection on your graph occurs at the volume of **FA 2** that reacted to form a neutral solution.

Determine the volumes of **FA 1** and **FA 2** required to form a neutral solution.

.............................. $cm^3$ of **FA 1** neutralises .............................. $cm^3$ of **FA 2**. [1]

**(c)** **(i)** Calculate the number of moles of sodium hydroxide, **FA 2**, required to obtain a neutral solution in this experiment.

moles of NaOH = .............................. mol [1]

**(ii)** Hence calculate the concentration of HZ in **FA 1**.

concentration of HZ = .............................. mol $dm^{-3}$ [1]

**(d)** Explain how you would use the data obtained to calculate the enthalpy change of neutralisation of HZ. You do not need to carry out the calculation.

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

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

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

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

............................................................................................................................. [3]

[Total: 12]

**2** You will now determine the concentration of HZ in **FA 1** by titration using aqueous sodium carbonate of known concentration.

$$2H^+(aq) + CO_3^{2-}(aq) \rightarrow H_2O(l) + CO_2(g)$$

**FA 3** is 0.0353 mol dm$^{-3}$ aqueous sodium carbonate, $Na_2CO_3$.
methyl orange indicator

**(a) Dilution of FA 1**

- Use the 10.0 cm$^3$ pipette to transfer 10.0 cm$^3$ of **FA 1** into the 250 cm$^3$ volumetric flask.
- Add distilled water to the mark.
- Shake the flask to mix the solution thoroughly and label it **FA 4**.

**Titration**

- Fill the second burette with **FA 4**.
- Pipette 25.0 cm$^3$ of **FA 3** into a conical flask.
- Add approximately 10 drops of methyl orange.
- 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 certain that any recorded results show the precision of your practical work.
- Record all of your burette readings and the volume of **FA 4** added in each accurate titration.

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

[7]

**(b)** From your accurate titration results, obtain a suitable value for the volume of **FA 4** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm$^3$ of **FA 3** required ............................. cm$^3$ of **FA 4**. [1]

**(c)** **(i)** Give your answers to **(ii)**, **(iii)** and **(iv)** to an appropriate number of significant figures. [1]

**(ii)** Calculate the number of moles of sodium carbonate in the **FA 3** pipetted into the conical flask.

moles of $Na_2CO_3$ = .............................. mol [1]

**(iii)** Deduce the number of moles of HZ present in the volume of **FA 4** recorded in **(b)**.

moles of HZ = .............................. mol [1]

**(iv)** Calculate the concentration of HZ present in **FA 1**.

concentration of HZ in **FA 1** = .............................. mol dm$^{-3}$ [1]

**(d)** In **Question 1** you determined the concentration of HZ in **FA 1** by a thermometric method.
In **Question 2** you determined the concentration of HZ in **FA 1** by titration.
Tick which one of the following statements you believe to be true.

| | |
|---|---|
| The method in **Question 1** is more accurate than the method in **Question 2**. | |
| The method in **Question 2** is more accurate than the method in **Question 1**. | |
| The two methods are of equal accuracy. | |

Explain your answer.

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

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

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

**(e)** A teacher informed a class that 112.3 g of pure HZ had been dissolved in distilled water to make 1 $dm^3$ of **FA 1**. A student in the class suggested that HZ could be ethanoic acid.

Using your answer to **(c)(iv)** show, by calculation, whether the student was correct.
(If you were unable to complete the calculation in **(c)(iv)** you may assume the concentration was 2.08 mol $dm^{-3}$. This is not the correct value.)

The student was correct / incorrect because ..............................................................................

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

[Total: 14]

**Qualitative Analysis**

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

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

- colour changes seen;
- the formation of any precipitate and its solubility in an excess of the reagent added;
- the formation of any gas and its identification by a suitable test.

You should indicate clearly at what stage in a test a change occurs.

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

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

**No additional tests for ions present should be attempted.**

3 (a) **FA 5**, **FA 6** and **FA 7** are solutions each containing one cation and one anion. One of the cations and all of the anions are listed in the Qualitative Analysis Notes. You will carry out a series of tests on **FA 5**, **FA 6** and **FA 7** and draw conclusions from your observations.
Use a separate 1 cm depth of each solution in a test-tube for the following tests.

| *test* | *observations* | | |
|---|---|---|---|
| | **FA 5** | **FA 6** | **FA 7** |
| Add a 1 cm depth of aqueous sodium carbonate. | | | |
| Add a 1 cm length of magnesium ribbon. | | | |
| Add 2 or 3 drops of aqueous silver nitrate, then | | | |
| add aqueous ammonia. | | | |
| Add a 1 cm depth of aqueous barium nitrate, then | | | |
| add a 1 cm depth of dilute hydrochloric acid. | | | |

| *test* | *observations* | | |
|---|---|---|---|
| | **FA 5** | **FA 6** | **FA 7** |
| Add aqueous sodium hydroxide. | | | |
| Add a 1 cm depth of **FA 7**. | | | |

[10]

**(b)** Use your observations from **(a)** to identify as many ions as possible. Give the formula of each ion present. Write 'unknown' if you were unable to make a positive identification of an ion.

| | **FA 5** | **FA 6** | **FA 7** |
|---|---|---|---|
| cation | | | |
| anion | | | |

[3]

**(c)** Give the ionic equation for any precipitation reaction involving **FA 5** that you observed in **(a)**. Include state symbols.

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

[Total: 14]

## Qualitative Analysis Notes

### 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) | faint white ppt. is nearly always observed unless 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 | 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

| *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 |
| sulfate, $SO_4^{2-}(aq)$ | gives white ppt. with $Ba^{2+}(aq)$ (insoluble in excess dilute strong acids) |
| sulfite, $SO_3^{2-}(aq)$ | 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 |

## The Periodic Table of Elements

**Key**

atomic number
atomic symbol
name
relative atomic mass

| Group 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 H hydrogen 1.0 | | | | | | | | | | 2 He helium 4.0 |
| 3 Li lithium 6.9 | 4 Be beryllium 9.0 | | | | | | | | | | | 5 B boron 10.8 | 6 C carbon 12.0 | 7 N nitrogen 14.0 | 8 O oxygen 16.0 | 9 F fluorine 19.0 | 10 Ne neon 20.2 |
| 11 Na sodium 23.0 | 12 Mg magnesium 24.3 | | | | | | | | | | | 13 Al aluminium 27.0 | 14 Si silicon 28.1 | 15 P phosphorus 31.0 | 16 S sulfur 32.1 | 17 Cl chlorine 35.5 | 18 Ar argon 39.9 |
| 19 K potassium 39.1 | 20 Ca calcium 40.1 | 21 Sc scandium 45.0 | 22 Ti titanium 47.9 | 23 V vanadium 50.9 | 24 Cr chromium 52.0 | 25 Mn manganese 54.9 | 26 Fe iron 55.8 | 27 Co cobalt 58.9 | 28 Ni nickel 58.7 | 29 Cu copper 63.5 | 30 Zn zinc 65.4 | 31 Ga gallium 69.7 | 32 Ge germanium 72.6 | 33 As arsenic 74.9 | 34 Se selenium 79.0 | 35 Br bromine 79.9 | 36 Kr krypton 83.8 |
| 37 Rb rubidium 85.5 | 38 Sr strontium 87.6 | 39 Y yttrium 88.9 | 40 Zr zirconium 91.2 | 41 Nb niobium 92.9 | 42 Mo molybdenum 95.9 | 43 Tc technetium – | 44 Ru ruthenium 101.1 | 45 Rh rhodium 102.9 | 46 Pd palladium 106.4 | 47 Ag silver 107.9 | 48 Cd cadmium 112.4 | 49 In indium 114.8 | 50 Sn tin 118.7 | 51 Sb antimony 121.8 | 52 Te tellurium 127.6 | 53 I iodine 126.9 | 54 Xe xenon 131.3 |
| 55 Cs caesium 132.9 | 56 Ba barium 137.3 | 57–71 lanthanoids | 72 Hf hafnium 178.5 | 73 Ta tantalum 180.9 | 74 W tungsten 183.8 | 75 Re rhenium 186.2 | 76 Os osmium 190.2 | 77 Ir iridium 192.2 | 78 Pt platinum 195.1 | 79 Au gold 197.0 | 80 Hg mercury 200.6 | 81 Tl thallium 204.4 | 82 Pb lead 207.2 | 83 Bi bismuth 209.0 | 84 Po polonium – | 85 At astatine – | 86 Rn radon – |
| 87 Fr francium – | 88 Ra radium – | 89–103 actinoids | 104 Rf rutherfordium – | 105 Db dubnium – | 106 Sg seaborgium – | 107 Bh bohrium – | 108 Hs hassium – | 109 Mt meitnerium – | 110 Ds darmstadtium – | 111 Rg roentgenium – | 112 Cn copernicium – | | 114 Fl flerovium – | | 116 Lv livermorium – | | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lanthanoids | 57 La lanthanum 138.9 | 58 Ce cerium 140.1 | 59 Pr praseodymium 140.9 | 60 Nd neodymium 144.4 | 61 Pm promethium – | 62 Sm samarium 150.4 | 63 Eu europium 152.0 | 64 Gd gadolinium 157.3 | 65 Tb terbium 158.9 | 66 Dy dysprosium 162.5 | 67 Ho holmium 164.9 | 68 Er erbium 167.3 | 69 Tm thulium 168.9 | 70 Yb ytterbium 173.1 | 71 Lu lutetium 175.0 |
| actinoids | 89 Ac actinium – | 90 Th thorium 232.0 | 91 Pa protactinium 231.0 | 92 U uranium 238.0 | 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 – |