

Cambridge
International
AS & A Level

Cambridge Assessment International Education
 Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE
NAME

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CENTRE
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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 | |
| | |

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| For Examiner's Use | |
| 1 | |
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| 3 | |
| Total | |

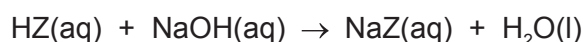
This document consists of **12** printed pages.

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.



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.

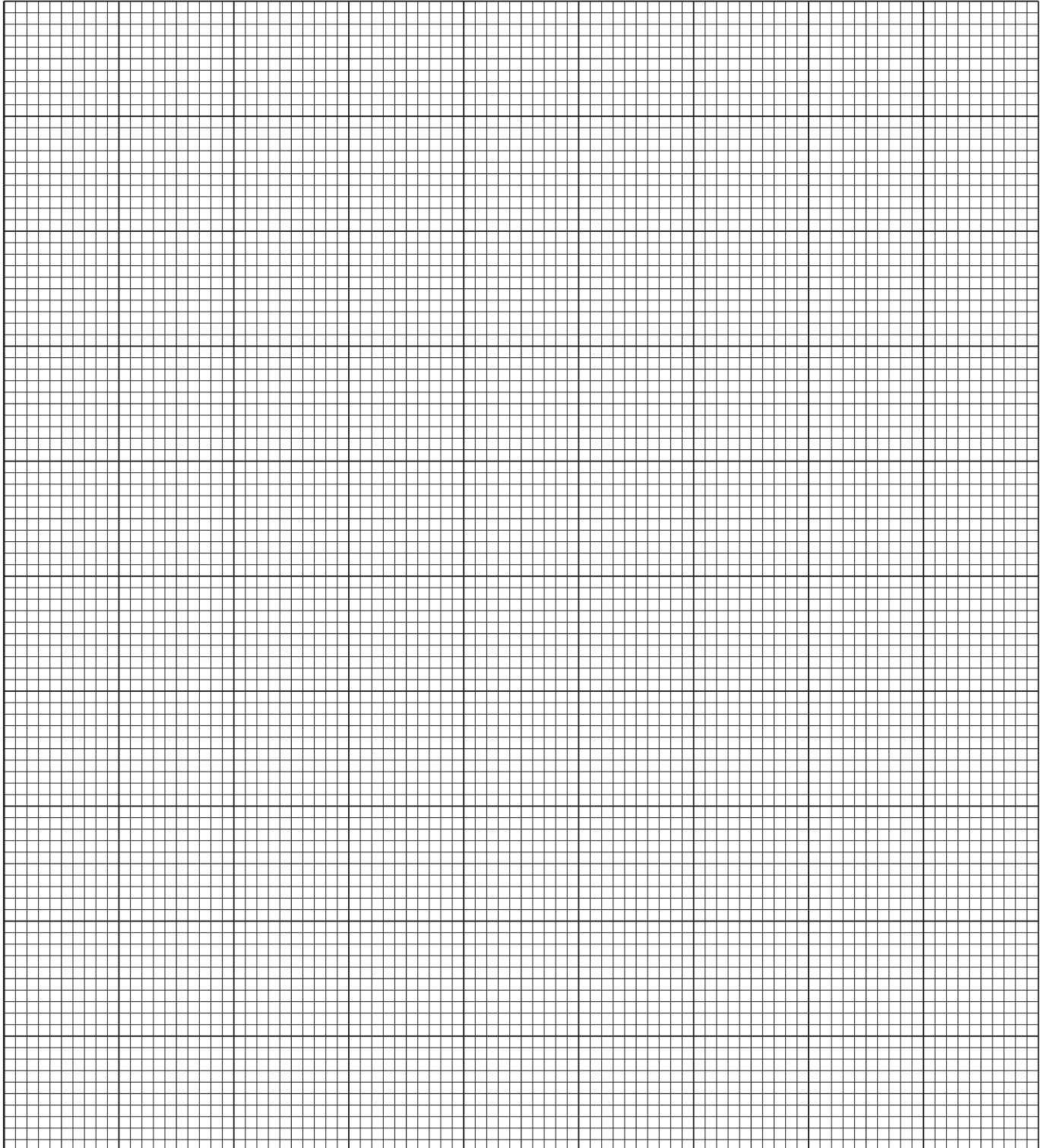
| | | | | | | | | | |
|------------------------------------|------|------|------|------|------|------|------|------|------|
| volume FA 1 / cm^3 | 40.0 | 35.0 | 30.0 | 25.0 | 20.0 | 15.0 | 10.0 | 5.0 | 0.0 |
| volume FA 2 / cm^3 | 0.0 | 5.0 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 |
| temperature / $^{\circ}\text{C}$ | | | | | | | | | |

[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.

..... cm³ of **FA 1** neutralises cm³ 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**.

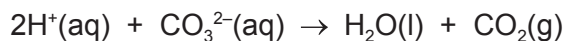
concentration of HZ = mol dm⁻³ [1]

- (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.

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

[Total: 12]

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



FA 3 is $0.0353 \text{ mol dm}^{-3}$ 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 $\text{Na}_2\text{CO}_3 = \dots\dots\dots$ mol [1]

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

moles of HZ = $\dots\dots\dots$ mol [1]

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

concentration of HZ in **FA 1** = $\dots\dots\dots$ 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 . | <input type="checkbox"/> |
| The method in Question 2 is more accurate than the method in Question 1 . | <input type="checkbox"/> |
| The two methods are of equal accuracy. | <input type="checkbox"/> |

Explain your answer.

.....

.....

.....

[1]

- (e) A teacher informed a class that 112.3g of pure HZ had been dissolved in distilled water to make 1 dm³ 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.

| <i>test</i> | <i>observations</i> | | |
|--|---------------------|-------------|-------------|
| | FA 5 | FA 6 | FA 7 |
| Add a 1 cm depth of aqueous sodium carbonate. | X | | |
| Add a 1 cm length of magnesium ribbon. | X | | |
| 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. | | | |

| <i>test</i> | <i>observations</i> | | |
|-----------------------------------|---------------------|-------------|-------------|
| | FA 5 | FA 6 | FA 7 |
| Add aqueous sodium hydroxide. | | | |
| Add a 1 cm depth of FA 7 . | | | X |

[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

| <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 |
| sulfate, $\text{SO}_4^{2-}(\text{aq})$ | gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids) |
| sulfite, $\text{SO}_3^{2-}(\text{aq})$ | 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 |

The Periodic Table of Elements

| | | Group | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|----|-------------------------|---|-------------------------|--------|-------------------------|-----|--------------------------|-----|-------------------------|-----|--------------------------|-----|-------------------------|-----|--------------------------|-----|------------------------|-----|--------------------------|-----|-------------------------|--------|-------------------------|-----|--------------------------|-----|-------------------------|-----|--------------------------|-----|--------------------------|-----|--------------------------|-----|------------------------|-----|--------------------------|-----|------------------------|-----|------------------------|-----|-------------------------|-----|-------------------------|----|-------------------------|----|--------------------------|----|-----------------------|----|-----------------------|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
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| 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 — | | | | | | | | | | | | | | | | | | |
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| 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 — | | | | | | | | | | | | | | | | | | | | | | | | | | |

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| 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 |
| 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 — |

lanthanoids

actinoids