CAMBRIDGE
International Education

# Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

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**CHEMISTRY** **9701/31**

Paper 3 Advanced Practical Skills 1 **May/June 2026**

**2 hours**

You must answer on the question paper.

You will need: The materials and apparatus listed in the confidential instructions

**INSTRUCTIONS**

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen. Do **not** use correction fluid or tape.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

**INFORMATION**

- The total mark for this paper is 40.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.
- Important values, constants and standards are printed in the question paper.
- Notes for use in qualitative analysis are provided in the question paper.

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

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

This document has **12** pages.

DC (CE) 350743/4


**[Turn over**

**Qualitative analysis**

For each test, you should record all your observations in the spaces provided.

Examples of observations include:

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

You should record clearly at what stage in a test an observation is made.

Where no change is observed, you should write 'no change'.

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

If any solution is warmed, a boiling tube must be used. If a solid is heated, a hard-glass test-tube must be used.

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

No additional tests should be attempted.

**1 (a)** **FA 1** is a solution containing one anion and one cation, both of which are listed in the Qualitative analysis notes.

**(i)** Carry out the following tests and record your observations in Tables 1.1 and 1.2. For each test use a 1 cm depth of **FA 1** in a test-tube.

**Table 1.1**

| test | observations |
|---|---|
| **Test 1**<br>Add aqueous sodium hydroxide,<br>then | |
| add a few drops of acidified aqueous potassium manganate(VII) and shake the tube,<br>then | |
| add a few drops of aqueous hydrogen peroxide. | |
| **Test 2**<br>Add aqueous ammonia. | |

 

**Table 1.2**

| test | observations |
|---|---|
| **Test 3**<br>Add a few drops of aqueous silver nitrate,<br>then | |
| add aqueous ammonia. | |
| **Test 4**<br>Add 1 cm depth of aqueous sodium carbonate,<br>then | |
| add dilute nitric acid. | |

[6]

**(ii)** Deduce the formulae of the ions present in **FA 1**.

cation ..... anion .....

[1]

**(iii)** Write an ionic equation for **one** of the reactions in Test 4. Include state symbols.

..... [1]

**(iv)** Explain why the addition of aqueous ammonia in Test 3 does **not** help you to identify the anion.

.....

..... [1]

**(b)** **FA 2** is a solution containing one cation and one anion, both of which are listed in the Qualitative analysis notes. The anion contains only elements in Group 16 of the Periodic Table.

**(i)** Carry out tests to identify both of the ions in **FA 2**.
Record your tests and observations in a suitable form.

[5]

**(ii)** Deduce the formula of **FA 2**.

**FA 2** ..... [1]

[Total: 15]



 

## 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 the precision of the apparatus you used in the data you record.

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

**2** **FA 3** is a hydrated salt. **FA 3** was dissolved in water to prepare the **FA 2** used in **Question 1**.

**FA 3** decomposes when heated, losing its water of crystallisation.
You will determine the formula of **FA 3** by heating it until it becomes anhydrous.

**(a) Method**

- Weigh the empty crucible with its lid. Record the mass in the results section.
- Add 2.10–2.40 g of **FA 3** to the crucible.
- Weigh the crucible and lid with **FA 3**. Record the mass.
- Place the crucible on the pipeclay triangle. Heat the crucible and contents **gently**, with the lid on, for approximately 2 minutes.
- Remove the lid. Heat the crucible and contents strongly for approximately 5 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.

**While the crucible is cooling, you may wish to begin work on Question 3.**

- When the crucible is cool, weigh the crucible and contents with the lid on. Record the mass.
- Place the crucible on the pipeclay triangle. Remove the lid.
- Heat the crucible and contents strongly for a further 2 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.
- When the crucible is cool, reweigh the crucible and contents with the lid on. Record the mass.
- Calculate the mass of **FA 3** added to the crucible, the mass of residue obtained and the mass loss. Record these masses.

**Results**

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

[4]

**(b) Calculations**

**(i)** Calculate the amount, in mol, of water of crystallisation lost during the decomposition of **FA 3**.

amount of $H_2O$ lost = ..... mol [1]

**(ii)** Use the formula of **FA 2** in **1(b)(ii)** to calculate the relative formula mass, $M_r$, of the anhydrous salt of **FA 3**.

(If you were unable to identify **FA 2** in **1(b)(ii)**, then assume it is barium nitrate. This is **not** the correct identity.)

$M_r$ of anhydrous salt of **FA 3** = ..... [1]

**(iii)** Use your answer to **2(b)(ii)** to calculate the amount, in mol, of the anhydrous salt of **FA 3** produced by decomposition in your experiment in **2(a)**.

amount of anhydrous salt of **FA 3** = ..... mol [1]

**(iv)** Deduce the formula of the hydrated salt, **FA 3**.
Show your working.

**FA 3** ..... [1]

**(c) (i)** State the uncertainty in a single reading for the balance that you used.

uncertainty = ± ..... g

Calculate the maximum percentage error in your measurement of the mass of **FA 3**.
Show your working.

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



 

**(ii)** A student suggests that the experiment in **2(a)** will be more accurate if the mass of **FA 3** used is doubled.

Give **one** reason why the student's suggestion is **not** correct.

.....

.....

..... [1]

[Total: 10]

**3** You will determine the concentration of a solution of sulfuric acid by titration with aqueous potassium hydroxide.

**FA 4** is dilute sulfuric acid, $H_2SO_4$.
**FA 5** is aqueous potassium hydroxide containing 10.0 g $dm^{-3}$ KOH.
**FA 6** is bromophenol blue indicator.

**(a) Method**

Preparation of **FA 7**

- Pipette 25.0 $cm^3$ of **FA 4** into the 250 $cm^3$ volumetric flask.
- Make the solution up to 250 $cm^3$ with distilled water.
- Thoroughly mix the contents of the volumetric flask.
- This solution of sulfuric acid is **FA 7**.

Titration

- Fill the burette with **FA 7**.
- Rinse the pipette with distilled water and then with **FA 5**.
- Pipette 25.0 $cm^3$ of **FA 5** into a conical flask.
- Add a few drops of **FA 6** to the solution in the conical flask.
- Perform a rough titration and record your burette readings.

rough titre = ..... $cm^3$

- Carry out as many accurate titrations as you think necessary to obtain consistent results.
- Make sure any recorded results show the precision of your practical work.
- Record in a suitable form all your burette readings and the volume of **FA 7** added in each accurate titration.

**Results**

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

[7]

 

**(b)** From your accurate titration results, calculate a suitable mean value to use in your calculations. Show clearly how you obtain the mean value.

25.0 $cm^3$ of **FA 5** required ..... $cm^3$ of **FA 7**. [1]

**(c) Calculations**

**(i)** Give your answers to **3(c)(ii)**, **3(c)(iv)** and **3(c)(v)** to an appropriate number of significant figures. [1]

**(ii)** Calculate the amount, in mol, of potassium hydroxide in the volume of **FA 5** used in each titration.

amount of KOH = ..... mol [1]

**(iii)** Give the equation for the reaction taking place in the titration.
Include state symbols.

..... [1]

**(iv)** Calculate the concentration, in mol $dm^{-3}$, of sulfuric acid in **FA 7**.

concentration of $H_2SO_4$ = ..... mol $dm^{-3}$ [1]

**(v)** Calculate the mass, in g, of sulfuric acid in 1.00 $dm^3$ of **FA 4**.

mass of $H_2SO_4$ = ..... g [1]

**(d)** A student carries out the procedure in **3(a)**. However, by mistake the student was given alkali containing 10.0 g $dm^{-3}$ of sodium hydroxide instead of 10.0 g $dm^{-3}$ of potassium hydroxide.

The student was **not** aware of this mistake. State and explain what effect the wrong alkali has on the concentration of **FA 7** that the student calculates in **3(c)(iv)**.

.....

.....

.....

..... [2]

[Total: 15]

 

**Qualitative analysis notes**

## Reactions of cations

| cation | 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.<br>ammonia produced on warming | – |
| barium, $Ba^{2+}$(aq) | faint white ppt. is observed unless [$Ba^{2+}$(aq)] is very low | no ppt. |
| calcium, $Ca^{2+}$(aq) | white ppt. unless [$Ca^{2+}$(aq)] is very low | 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 | pale blue ppt. soluble in excess giving dark blue solution |
| iron(II), $Fe^{2+}$(aq) | green ppt. turning brown on contact with air<br>insoluble in excess | green ppt. turning brown on contact with air<br>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<br>insoluble in excess | off-white ppt. rapidly turning brown on contact with air<br>insoluble in excess |
| zinc, $Zn^{2+}$(aq) | white ppt. soluble in excess | white ppt. soluble in excess |

## Reactions of anions

| anion | 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 / off-white ppt. with $Ag^+$(aq) (partially soluble in $NH_3$(aq)) |
| iodide, $I^-$(aq) | gives pale 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;<br>decolourises acidified aqueous $KMnO_4$ |
| sulfate, $SO_4^{2-}$(aq) | gives white ppt. with $Ba^{2+}$(aq) (insoluble in excess dilute strong acids);<br>gives white ppt. with high [$Ca^{2+}$(aq)] |
| sulfite, $SO_3^{2-}$(aq) | gives white ppt. with $Ba^{2+}$(aq) (soluble in excess dilute strong acids);<br>decolourises acidified aqueous $KMnO_4$ |
| thiosulfate, $S_2O_3^{2-}$(aq) | gives off-white / pale yellow ppt. slowly with $H^+$ |

 

## 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 |
| hydrogen, $H_2$ | 'pops' with a lighted splint |
| oxygen, $O_2$ | relights a glowing splint |

## Tests for elements

| element | test and test result |
|---|---|
| iodine, $I_2$ | gives blue-black colour on addition of starch solution |

## Important values, constants and standards

| | |
|---|---|
| molar gas constant | $R = 8.31\,J\,K^{-1}\,mol^{-1}$ |
| Faraday constant | $F = 9.65 \times 10^{4}\,C\,mol^{-1}$ |
| Avogadro constant | $L = 6.022 \times 10^{23}\,mol^{-1}$ |
| electronic charge | $e = -1.60 \times 10^{-19}\,C$ |
| molar volume of gas | $V_m = 22.4\,dm^3\,mol^{-1}$ at s.t.p. (101 kPa and 273 K)<br>$V_m = 24.0\,dm^3\,mol^{-1}$ at room conditions |
| ionic product of water | $K_w = 1.00 \times 10^{-14}\,mol^2\,dm^{-6}$ (at 298 K (25 °C)) |
| specific heat capacity of water | $c = 4.18\,kJ\,kg^{-1}\,K^{-1}$ ($4.18\,J\,g^{-1}\,K^{-1}$) |

 

# The Periodic Table of Elements

| Group | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | | | | | | | | | | | 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 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 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 – | 113 Nh nihonium – | 114 Fl flerovium – | 115 Mc moscovium – | 116 Lv livermorium – | 117 Ts tennessine – | 118 Og oganesson – |

**Key**

atomic number
**atomic symbol**
name
relative atomic mass

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| lanthanoids | 57 La lanthanum 138.9 | 58 Ce cerium 140.1 | 59 Pr praseodymium 140.9 | 60 Nd neodymium 144.2 | 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 – |