Cambridge Assessment
International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER					

CHEMISTRY **9701/36**

Paper 3 Advanced Practical Skills 2 **October/November 2025**

2 hours

You must answer on the question paper.

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

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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 or correction fluid.
- 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. Any blank pages are indicated.

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 final answer to **each** step of your calculations.

1 Many hydrated salts decompose when heated, losing water of crystallisation.
The number of molecules of water of crystallisation, **x**, in hydrated aluminium sulfate can be determined by heating until it becomes anhydrous: **x** is an integer.

$$\mathrm{A}l_2(\mathrm{SO_4})_3{\bullet}\mathbf{x}\mathrm{H_2O(s)} \rightarrow \mathrm{A}l_2(\mathrm{SO_4})_3\mathrm{(s)} + \mathbf{x}\mathrm{H_2O(g)}$$

FB 1 is hydrated aluminium sulfate, $\mathrm{A}l_2(\mathrm{SO_4})_3{\bullet}\mathbf{x}\mathrm{H_2O}$.

(a) Method

- Weigh the crucible with its lid. Record the mass.
- Add between 1.80 and 2.00 g of **FB 1** to the crucible.
- Weigh the crucible, lid and **FB 1**. Record the mass.
- Place the crucible on the pipeclay triangle. Gently heat the crucible and contents for approximately 2 minutes with the lid on.
- Remove the lid. Heat the crucible and contents strongly for approximately 5 minutes.
- Replace the lid and leave the crucible and residue to cool for at least 5 minutes.

While the crucible is cooling, you should begin work on Questions 2 or 3.

- Reweigh the crucible and contents with the lid on. Record the mass.
- Remove the lid. Heat the crucible and contents strongly for a further 2 minutes.
- Replace the lid and leave the crucible and residue to cool for at least 5 minutes.
- Reweigh the crucible and residue with the lid on. Record the mass.
- Calculate and record the mass of **FB 1** used, the mass of residue obtained and the mass lost during heating.

Results

I	
II	
III	
IV	
V	

[5]

(b) Calculations

(i) Calculate the amount, in mol, of water of crystallisation lost during the thermal decomposition of **FB 1**.

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

(ii) Calculate the amount, in mol, of anhydrous residue produced by the thermal decomposition. Show your working.

amount of $Al_2(SO_4)_3$ produced = ... mol [1]

(iii) Calculate the number of molecules of water of crystallisation in the formula of hydrated aluminium sulfate, $Al_2(SO_4)_3 \bullet \mathbf{x}H_2O$.

x = ... [1]

(c) (i) State how the appearance of the residue compares with the appearance of the hydrated solid before heating.

....

.... [1]

(ii) Suggest why the crucible and contents are heated with the crucible lid **on** for the first two minutes of the experiment.

....

....

.... [1]

(iii) A student carries out the experiment in **(a)**, but obtains a value for **x** that is higher than expected. The student suggests that this could be because the hydrated aluminium sulfate is contaminated with some anhydrous aluminium sulfate.

State whether the student's suggestion is correct.
Explain your answer.

....

....

.... [1]

[Total: 11]

2 The number of molecules of water of crystallisation, **y**, in hydrated iron(II) sulfate can be determined by titration with acidified potassium manganate(VII): **y** is an integer.

FB 2 is aqueous iron(II) sulfate, containing 30.00 g dm^{-3} of $FeSO_4$•**y**H_2O.
FB 3 is aqueous potassium manganate(VII), containing 3.48 g dm^{-3} of $KMnO_4$.
FB 4 is 1.0 mol dm^{-3} sulfuric acid, H_2SO_4.

(a) Method

- Fill the burette with **FB 3**.
- Pipette 25.0 cm^3 of **FB 2** into a conical flask.
- Use the 25 cm^3 measuring cylinder to transfer approximately 10 cm^3 of **FB 4** to the conical flask.
- 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 sure any recorded results show the precision of your practical work.
- Record, in a suitable form below, all your burette readings and the volume of **FB 3** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, calculate a suitable mean value to be used in your calculations.
Show clearly how you obtained this value.

25.0 cm^3 of **FB 2** required .... cm^3 of **FB 3**. [1]

(c) **Calculations**

(i) Calculate the amount, in mol, of potassium manganate(VII) present in the volume of **FB 3** in **(b)**. Show your working.

amount of $KMnO_4$ = ... mol [2]

(ii) An incomplete equation for the reaction of iron(II) ions with manganate(VII) ions is shown. The mole ratio of Fe^{2+} and MnO_4^- is given correctly.
Complete the equation.

$5Fe^{2+}(aq) + MnO_4^-(aq) + ... H^+(aq) \rightarrow .... Fe^{3+}(aq) + Mn^{2+}(aq) + ...H_2O(l)$ [1]

(iii) Calculate the concentration of iron(II) sulfate, in mol dm^{-3}, in **FB 2**.

concentration of $FeSO_4$ = ... mol dm^{-3} [1]

(iv) Calculate the value of **y** in $FeSO_4•\mathbf{y}H_2O$.

y = ... [2]

(d) A student suggests that the experiment is more accurate if **FB 4** is measured with a pipette.

State whether you agree with the student.
Explain your answer.

....

....

.... [1]

(e) Aqueous solutions of iron(II) sulfate are slowly oxidised by air.
State what effect this oxidation would have on the value of **y** calculated in **(c)(iv)**.
Explain your answer.

....

....

.... [1]

[Total: 16]

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.

3 **(a)** **(i)** Use very small quantities of solid **FB 5** and carry out each of the tests described in Table 3.1. Identify any gases produced.

Table 3.1

test	*observations*
Test 1 Pour a 1 cm depth of aqueous iron(III) chloride into a test-tube. Add a small spatula measure of **FB 5**. Leave the test-tube to stand for about 3 minutes, then	
pour off some of the solution into another test-tube and add aqueous sodium hydroxide.	
Test 2 Pour a 1 cm depth of aqueous copper(II) sulfate into a test-tube. Add a small quantity of **FB 5**. Leave the test-tube to stand for about 3 minutes.	
Test 3 Pour a 1 cm depth of dilute sulfuric acid into a test-tube and add 2 drops of aqueous copper(II) sulfate. Then add a small quantity of **FB 5**.	

[4]

(ii) **FB 6** is the filtrate obtained after filtering the mixture that remains at the end of **Test 3** in **(a)(i)**.
Add aqueous ammonia to **FB 6**.
Record your observations.

....

.... [1]

(iii) Identify **FB 5**.

FB 5 is .... [1]

(iv) Using your observations, explain why the reaction in **Test 2** is a redox reaction.

....

.... [1]

(v) Give the ionic equation for the first reaction observed in **(a)(ii)**. Include state symbols.

.... [1]

(b) **FB 7** contains one anion and one cation. The anion contains oxygen but not nitrogen.
Both ions are listed in the Qualitative analysis notes.

(i) Transfer a small spatula measure of **FB 7** into a hard-glass test-tube.
Heat gently at the start, then strongly until no further change occurs.
Leave the test-tube to cool.

Record all your observations. Identify any gases produced.

....

....

....

....

.... [3]

(ii) Carry out **one** further positive test to confirm the identity of the **anion** in **FB 7**.

Record **only** the results shown in a positive test.
Describe the test you carry out and the observations you make in the space below.

The anion in **FB 7** is .... [2]

[Total: 13]

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Qualitative analysis notes

1 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. 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 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

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; decolourises acidified aqueous $KMnO_4$
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids); 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); decolourises acidified aqueous $KMnO_4$
thiosulfate, $S_2O_3^{2-}$(aq)	gives off-white / pale yellow ppt. slowly with H^+

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

4 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	$L = 6.02 \times 10^{23}\,mol^{-1}$
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) $V_m = 24.0\,dm^3\,mol^{-1}$ 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

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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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 –