CAMBRIDGE
International Education

Cambridge International AS & A Level

CANDIDATE NAME

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CHEMISTRY **9701/32**

Paper 3 Advanced Practical Skills 2 **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.

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[Turn over

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.

1 You will carry out a thermometric experiment to find the enthalpy change of reaction, ΔH_r, when aqueous copper(II) sulfate reacts with an excess of metal **M**.

FB 1 is 0.95 mol dm^{-3} copper(II) sulfate, $CuSO_4$.
FB 2 is metal **M**.

(a) Method

- Support the cup in the 250 cm^3 beaker.
- Use the 25 cm^3 measuring cylinder to transfer 25.0 cm^3 of **FB 1** into the cup.
- Place the thermometer in the **FB 1** and tilt the cup, if necessary, so that the bulb of the thermometer is fully covered. Record in Table 1.1 the temperature of **FB 1** in the cup. This is the temperature at time, t = 0.
- Start the stop-clock and record the temperature every 30 seconds for 1.5 minutes. Do **not** switch off the stop-clock.
- At 2.0 minutes, add all the **FB 2** to the cup and stir the mixture.
- Record the temperature every 30 seconds from 2.5 minutes until 10.0 minutes.
- Stir the mixture for at least 10 seconds before each thermometer reading.

Keep the contents of the cup for use in 1(c)(i).

Results

Table 1.1

time, *t* / minutes	0	0.5	1.0	1.5	2.0	2.5	3.0
temperature / °C							

time, *t* / minutes	3.5	4.0	4.5	5.0	5.5	6.0	6.5
temperature / °C							

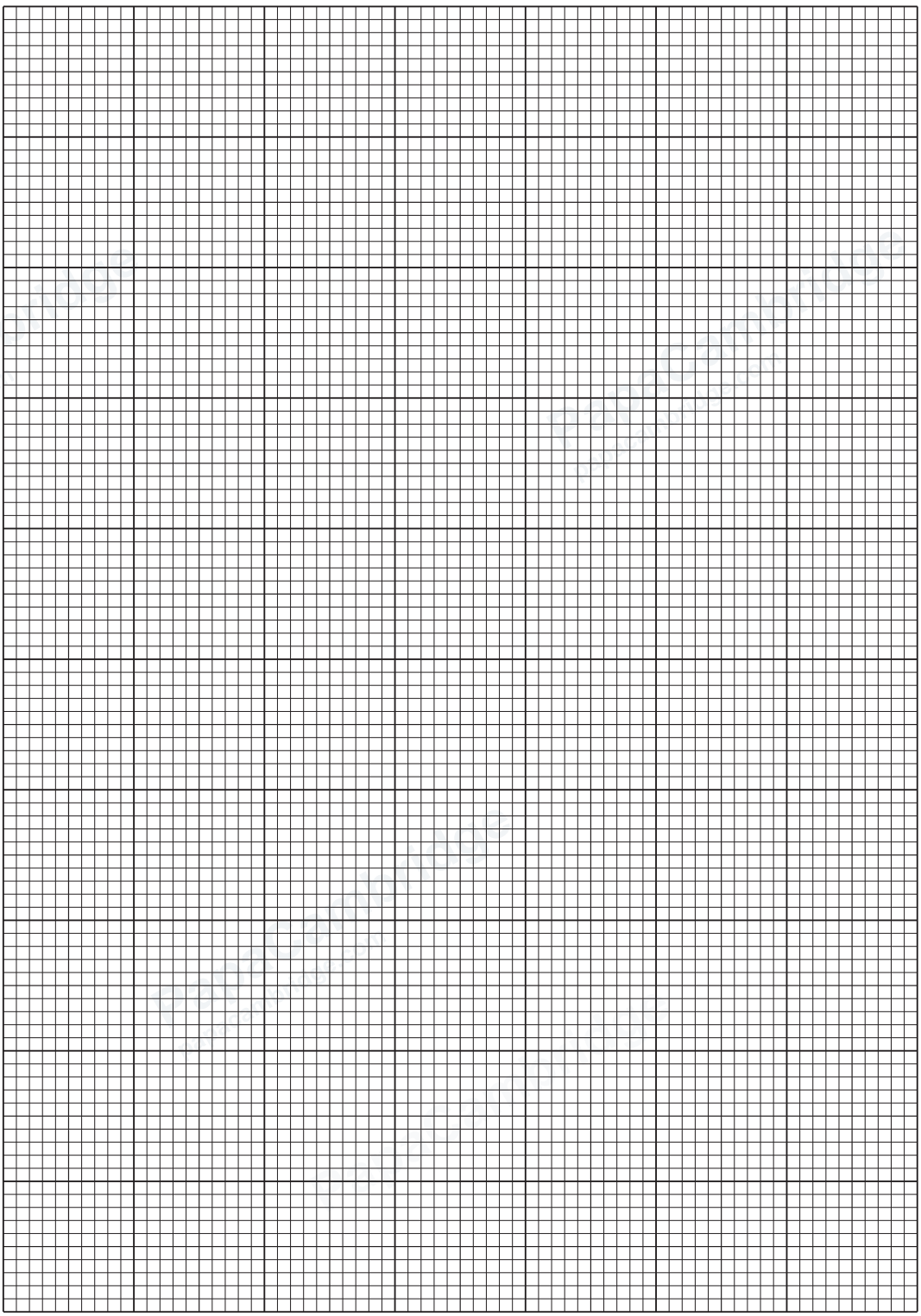
time, *t* / minutes	7.0	7.5	8.0	8.5	9.0	9.5	10.0
temperature / °C							

[3]

I		II		III	

(b) (i) Plot a graph of temperature (*y*-axis) against time (*x*-axis) on the grid. The scale on the *y*-axis should include a temperature 10.0 °C above your highest recorded temperature. Label any points that you consider anomalous.

Draw **two** lines of best fit, one for the points before the addition of **FB 2** and the other for the points after the highest recorded temperature has been reached. Extrapolate the two lines to time, t = 2.0 minutes.



I	
II	
III	
IV	

[4]

(ii) Use your graph in **1(b)(i)** to determine the maximum increase in temperature, ΔT.
Show clearly **on the grid** how you obtain this value.

ΔT = ... °C [1]

(c) (i) Wash the measuring cylinder with water to remove any **FB 1**.
Stir and immediately filter the contents of the cup into the measuring cylinder.
Record your observations.

appearance of filtrate .....

appearance of residue .....
[1]

(ii) Add an equal volume of distilled water to the filtrate from **1(c)(i)**.
Carry out test(s) to determine the identity of metal **M** using the diluted filtrate from **1(c)(i)**.
The cation of **M** is listed in the Qualitative analysis notes.
Record your test(s), observations and conclusion in a suitable form in the space below.

metal **M** .....
[3]

(d) Calculations

(i) Write an ionic equation for the reaction between **FB 1** and **FB 2**.
Include state symbols.

..... [1]

(ii) Calculate the energy change, in J, for the reaction.

energy change = ... J [1]

(iii) Calculate the enthalpy change, ΔH_r, in $kJ\,mol^{-1}$, for the reaction.

ΔH_r = ... $kJ\,mol^{-1}$ [2]
sign *value*

[Total: 16]

2 In this experiment you will find the value of integer **x** in $CuSO_4 \cdot \mathbf{x}H_2O$ by a gravimetric method.

$$CuSO_4 \cdot \mathbf{x}H_2O(s) \rightarrow CuSO_4(s) + \mathbf{x}H_2O(g)$$

FB 3 is hydrated copper(II) sulfate, $CuSO_4 \cdot \mathbf{x}H_2O$.

(a) Method

- Weigh the empty crucible with its lid. Record the mass in the space for results.
- Transfer all the **FB 3** from the container into the crucible.
- Weigh the crucible, lid and **FB 3**. Record the mass.
- Calculate the mass of **FB 3** added. Record this mass.
- Place the crucible, lid and contents on the pipeclay triangle.
- Heat the crucible gently, with the lid on, for approximately 1 minute.
- Remove the lid. Heat the crucible strongly for a further 5 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.

During the cooling period, you may wish to begin work on Question 3.

- When the crucible is cool, weigh the crucible with its lid and contents. Record the mass.
- Place the crucible and contents on the pipeclay triangle. Remove the lid.
- Heat 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 with its lid and contents. Record the mass.
- Calculate and record the mass of residue obtained and the mass loss.

Keep the cooled residue for use in 2(c).

Results

I	
II	
III	
IV	

[4]

(b) Calculations

(i) Calculate the amount, in mol, of anhydrous copper(II) sulfate formed in **2(a)**.

amount of $CuSO_4$ = ... mol [1]

(ii) Calculate the amount, in mol, of water lost on heating **FB 3**.

amount of H_2O lost = ... mol

Hence, calculate the value of integer **x**.
Show your working.

x = ...
[2]

(c) Check that the crucible from **2(a)** is cool.
Add distilled water dropwise to the cooled residue in the crucible until approximately 2 cm^3 has been added.
Record your observations.

.....

.....

..... [2]

(d) A student carries out the method in **2(a)** using a more powerful Bunsen burner. The final residue is partly black.

(i) Suggest a reason for the formation of the black colour.

.....

..... [1]

(ii) State what effect the more powerful Bunsen burner would have on the value of **x** calculated. Explain your answer.

.....

..... [1]

[Total: 11]

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 **FB 4** is a mixture of two salts, **FB 5** and **FB 6**, each containing two ions. All the ions are listed in the Qualitative analysis notes.

(a) Place a spatula measure of **FB 4** into a hard-glass test-tube. Heat the test-tube, gently at first and then more strongly. Record all your observations.

.....

.....

.....

..... [3]

(b) Tip the remaining **FB 4** into a 100 cm^3 beaker. Wash the 25 cm^3 measuring cylinder with water then add approximately 15 cm^3 of distilled water to **FB 4** in the beaker. Stir the mixture for approximately 30 seconds.
Filter the mixture into a boiling tube. The residue is **FB 5**. You will use the filtrate, **FB 6**, in **3(c)**. Record the appearance of filtrate **FB 6**.

appearance of filtrate **FB 6** .....

Use a spatula to transfer some **FB 5** into a test-tube.
Add hydrochloric acid and record all your observations.

observations .....

.....

..... [3]

(c) Carry out the following tests on **FB 6** and record your observations in Table 3.1.

Transfer a 0.5 cm depth of **FB 6** into the second boiling tube for Test 1.
Transfer a 1 cm depth of **FB 6** into each of three test-tubes for Tests 2–4.

Table 3.1

test	observations
Test 1 To the portion in the second boiling tube, add excess aqueous sodium hydroxide, then	
warm the mixture, then	
carefully transfer a 2 cm depth of the heated mixture into a test-tube and add a piece of aluminium foil.	
Test 2 Add aqueous ammonia.	
Test 3 Add a few drops of aqueous barium chloride or aqueous barium nitrate.	
Test 4 Carry out **one** further test to confirm the identity of the anion present in **FB 6**. Record your test and observations.	

[5]

(d) Use your observations in **3(a)**, **3(b)** and **3(c)** to identify the ions present in **FB 5** and **FB 6**. Write the formulae of the ions in Table 3.2. If you are unable to positively identify an ion, write 'unknown'.

Table 3.2

	cation	anion
FB 5		
FB 6		

[2]

[Total: 13]

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. 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

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^+

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

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 –