Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER		CANDIDATE NUMBER	

* 4 9 8 1 2 3 2 8 3 9 *

CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **October/November 2022**

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 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.

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

1 You are to determine the enthalpy change for a metal displacement reaction using a known volume and concentration of copper(II) sulfate and an excess of powdered zinc.

$$Cu^{2+}(aq) + Zn(s) \rightarrow Zn^{2+}(aq) + Cu(s)$$

FB 1 is 0.80 mol dm^{-3} copper(II) sulfate, $CuSO_4$.
FB 2 is zinc, Zn.

(a) Method

- Weigh the container with **FB 2**. Record the mass.
- Support the cup in the 250 cm^3 beaker.
- Use the 50 cm^3 measuring cylinder to transfer 30.0 cm^3 of **FB 1** into the cup.
- Place the thermometer in the solution. Measure and record the initial temperature of the solution. This is the temperature at time zero, $t = 0$.
- Start timing and do not stop the clock until the whole experiment has been completed.
- Measure and record the temperature of the solution every half minute for 2 minutes.
- At time $t = 2\frac{1}{2}$ minutes tip all the **FB 2** into the solution and stir the mixture.
- Measure and record the temperature of the mixture at $t = 3$ minutes and every half minute until $t = 9$ minutes. Stir the mixture between thermometer readings.
- Weigh the container with any residue of **FB 2**. Record the mass.
- Calculate and record the mass of **FB 2** added to the solution.

Results

time / minutes	0	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4
temperature / °C									

time / minutes	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9
temperature / °C										

I	
II	
III	
IV	

[4]

(b) **(i)** Plot a graph of temperature on the *y*-axis against time on the *x*-axis on the grid. The scale for temperature should extend 5 °C above your highest recorded temperature. You will use this graph to determine the theoretical maximum temperature rise at $2\frac{1}{2}$ minutes. [3]

(ii) Draw two lines of best fit through the points on your graph. The first line should be for the temperature before adding **FB 2** and the second for the cooling of the mixture.

Extrapolate the two lines to $2\frac{1}{2}$ minutes. Draw a vertical line at $2\frac{1}{2}$ minutes. Determine the theoretical rise in temperature at this time.

theoretical rise in temperature at $2\frac{1}{2}$ minutes = ... °C [2]

(c) Calculations

(i) Calculate the amount, in mol, of copper(II) sulfate in **FB 1** added to the cup in **(a)**.

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

(ii) Show that the amount of zinc you added was in excess.

[1]

(iii) Use your answer to **(b)(ii)** to calculate the heat energy, in joules, given out when **FB 2** is added to **FB 1**.

heat energy = ... J [1]

(iv) Calculate the enthalpy change of reaction, ΔH_r, for the reaction carried out in **(a)**. Show your working.

ΔH_r = ... $kJ\,mol^{-1}$

sign *value* [1]

(d) A student carries out two further experiments using method **(a)**. In the first experiment, **FB 1** is made using a fresh sample of hydrated copper(II) sulfate, $CuSO_4{\bullet}5H_2O$.
In the second experiment, **FB 1** is made using an **old** sample of hydrated copper(II) sulfate.

The same mass of solid is used to make the solutions in these experiments.

In the second experiment, the student obtains a value for ΔH_r that is 10.7 $kJ\,mol^{-1}$ greater in magnitude than the value from the first experiment.

Suggest what may be deduced about the formula of the **old** sample of hydrated copper(II) sulfate.

The water of crystallisation is greater than 5.	
The formula, $CuSO_4{\bullet}5H_2O$, is correct.	
The water of crystallisation is less than 5.	

Tick the appropriate box and explain your answer.

....

....

.... [2]

[Total: 15]

2 Many metal carbonates, such as copper(II) carbonate, exist as basic carbonates. These are a combination of the metal carbonate and a base of the metal.

A bottle is labelled copper(II) carbonate, $CuCO_3$. You will carry out a gravimetric experiment to see whether the formula given is correct.

$$CuCO_3(s) \rightarrow CuO(s) + CO_2(g)$$

FB 3 is copper(II) carbonate and may have the formula $CuCO_3$.

(a) Method

- Weigh a crucible with its lid. Record the mass.
- Add 1.50–1.80 g of **FB 3** to the crucible.
- Weigh the crucible and lid with **FB 3**. Record the mass.
- Place the crucible on the pipe-clay triangle. Heat the crucible, with the lid on, gently for approximately 1 minute and then strongly for another minute.
- Remove the lid. Heat the crucible strongly for about 4 minutes.
- Replace the lid and leave the crucible and residue to cool for at least 5 minutes.

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

- Reweigh the crucible and contents with its lid. Record the mass.
- Calculate and record the mass of **FB 3** added to the crucible.
- Calculate and record the mass of the residue obtained.

Keep the residue for use in 2(d).

Results

I	
II	
III	
IV	

[4]

(b) Calculations

(i) The residue obtained in **(a)** is copper(II) oxide.

Calculate the amount, in mol, of copper(II) oxide formed on heating.

amount of CuO = ... mol [1]

(ii) Calculate the mass lost on heating the copper carbonate.

mass lost = ... g

Assuming the formula for **FB 3** is $CuCO_3$, calculate the amount, in mol, of carbon dioxide lost on heating.

amount of CO_2 = ... mol
[1]

(iii) Use your answers to **(b)(i)** and **(b)(ii)** to explain whether the formula of **FB 3** is $CuCO_3$.

....

.... [1]

(c) Another bottle of copper(II) carbonate was labelled basic copper(II) carbonate but part of the label giving the formula had been torn and only showed '$CuCO_3$•Cu...'.

Suggest a formula for basic copper(II) carbonate.

One possible formula for basic copper(II) carbonate is .... [1]

(d) (i) It is possible that **FB 3** did not decompose fully on heating in **(a)**.

Explain how you would change the method used to ensure decomposition was complete.

....

.... [1]

(ii) Select a reagent to use to test whether your sample of **FB 3** has decomposed completely.

reagent ....

Carry out your test on the residue from **(a)**. Record your observations. State your conclusion.

....

....
[2]

[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.

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

No additional tests should be attempted.

3 Half-fill the 250 cm^3 beaker with water and place it on a tripod and gauze. Heat the water until boiling then switch off your Bunsen burner. This will be your hot water bath.

(a) **FB 4** is an aqueous solution containing one cation and one anion, both of which are listed in the Qualitative analysis notes.
FB 5 is an aqueous solution of an organic compound which contains a functional group which is one of an alcohol, an aldehyde or a carboxylic acid.

(i) For each test use a 1 cm depth of **FB 4** in a test-tube. Record all your observations.

test	*observations*
Test 1 Add aqueous ammonia, then	
add aqueous EDTA.	
Test 2 Add a 2 cm depth of aqueous EDTA, then	
add a few drops of aqueous sodium hydroxide, then	
add a 1 cm depth of **FB 5** and place the test-tube in the hot water bath.	

test	*observations*
Test 3 Add a strip of magnesium ribbon and leave the test-tube for 1 minute.	

[5]

(ii) The anion in **FB 4** is either a halide or an anion containing sulfur.
Select reagents to positively identify the anion.

Carry out your tests and record the reagents used and your observations in a suitable form below.

[3]

(iii) Identify the compound in **FB 4** from your observations.

The formula of **FB 4** is .... [1]

(iv) Give an ionic equation for a reaction in **Test 3**. Include state symbols.

.... [1]

(b) Reheat your water bath to boiling then switch off your Bunsen burner.

Prepare Tollens' solution for use in **Test 1** as follows:
Place a $\frac{1}{2}$cm depth of aqueous silver nitrate in a test-tube. Add 1 or 2 drops of aqueous sodium hydroxide to form a brown precipitate. Shake the tube then add aqueous ammonia dropwise with shaking until the precipitate just dissolves.

When you have completed **Test 1** pour the contents of the test-tube down the sink with plenty of water and rinse the test-tube.

(i) Use a 1cm depth of **FB 5** in a test-tube for each of the following tests.

test	*observations*
Test 1 Add a 1cm depth of Tollens' solution and place the test-tube in the hot water bath.	
Test 2 Add 1 or 2 drops of acidified aqueous potassium manganate(VII) and place the test-tube in the hot water bath.	
Test 3 Add a 1cm depth of aqueous sodium carbonate.	

[3]

(ii) **FB 5** contains a functional group which is either an alcohol, an aldehyde or a carboxylic acid.

State which functional group is present. Explain your answer.

....

.... [1]

[Total: 14]

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	$L = 6.022 \times 10^{23}\ mol^{-1}$
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) $V_m = 24.0\ dm^3\ mol^{-1}$ 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 144.4	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 –