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Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

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0381674472

CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **October/November 2024**

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	
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3	
Total	

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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 Iodine reacts with propanone in the presence of an acid catalyst. The rate of this reaction can be measured by determining how the concentration of iodine in the reaction mixture changes with time.

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + HI(aq)$$

A student studies this reaction by mixing together the following three solutions and immediately starting the stop-clock.

- $100.0\,cm^3$ of $0.1000\,mol\,dm^{-3}$ iodine, I_2
- $50.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ propanone, CH_3COCH_3
- $50.0\,cm^3$ of $1.00\,mol\,dm^{-3}$ sulfuric acid, H_2SO_4

The student removes $25.0\,cm^3$ of the solution. After 80 seconds, $50.0\,cm^3$ of a solution of sodium hydrogencarbonate, $NaHCO_3$, is added which reacts with all the sulfuric acid in the sample. Distilled water is added until the volume of the solution is $150.0\,cm^3$. This solution is **FB 1**.

In this experiment you will determine the concentration of iodine in **FB 1** and so determine the average rate of reaction during the first 80 seconds. You will do this by titration using sodium thiosulfate solution.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

FB 1 is a sample of the solution prepared by the student.
FB 2 is $0.0100\,mol\,dm^{-3}$ sodium thiosulfate, $Na_2S_2O_3$.
FB 3 is starch indicator.

(a) Method

- Fill the burette with **FB 2**.
- Pipette $25.0\,cm^3$ of **FB 1** into a conical flask.
- Run **FB 2** into the conical flask until the colour of the solution turns yellow. Then add 10 drops of **FB 3**. The solution will turn blue-black.
- The end-point of the titration is when the solution turns colourless.
- 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 all your burette readings and the volume of **FB 2** added in each accurate titration.

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Results

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

(c) Calculations

(i) Give your answers to each part of **(c)(ii)** and **(c)(iii)** to an appropriate number of significant figures. [1]

(ii) Use your answer to **(b)** to calculate the amount, in mol, of thiosulfate ions in your mean titre.

amount of $S_2O_3^{2-}$ = ... mol

Hence calculate the amount, in mol, of iodine present in the total volume of 150.0 cm^3 that the student prepares.

amount of I_2 = ... mol
[2]

(iii) Calculate the concentration, in mol dm^{-3}, of iodine in the sample that the student removes from the reaction mixture.

concentration of I_2 = ... mol dm^{-3} [1]

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(iv) Calculate the initial concentration of iodine in the reaction mixture.

(If you were unable to determine an answer to **(c)(iii)** use 0.0315 mol dm^{-3} as the concentration of I_2 in the sample the student removed.)

initial concentration of I_2 = ... mol dm^{-3}

Hence calculate the average rate of reaction during the first 80 seconds using the formula shown.

$$\text{average rate of reaction} = \frac{\text{change in the concentration of } I_2}{\text{time}}$$

average rate = ...
value *units*

[2]

(d) Suggest why the starch solution is added when the solution in the conical flask turns yellow and not added at the start of the titration.

.....

..... [1]

(e) A student suggests that the experimental procedure is incorrect. The student says that the sample should be removed from the reaction mixture at 80 seconds rather than the sodium hydrogencarbonate being added at 80 seconds.
State if you agree with this student. Explain your answer.

.....

.....

..... [1]

[Total: 16]

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2 In this experiment you will identify the ions in the hydrated salt $\mathbf{MA_2 \cdot 2H_2O}$, where **M** is a Group 2 metal. You will first determine the relative formula mass of the salt by measuring the mass loss when the sample is heated. Heating the sample produces the anhydrous salt and water of crystallisation. You will then select reagents to determine the identity of the ion $\mathbf{A^-}$.

FB 4 is the salt, $\mathbf{MA_2 \cdot 2H_2O}$.

(a) Method

- Weigh the empty crucible with its lid. Record the mass.
- Transfer all of **FB 4** into the crucible.
- Weigh the crucible, lid and **FB 4**. Record the mass.
- Calculate and record the mass of **FB 4** used.
- Place the crucible and contents on a pipe-clay triangle.
- Heat the crucible gently, with the lid on, for approximately 1 minute.
- Heat strongly, with the lid off, for a further 4 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 has cooled, weigh the crucible with its lid and contents. Record the mass.
- Heat strongly, with the lid off, for a further 2 minutes.
- Replace the lid and leave the crucible to cool for at least 5 minutes.
- When the crucible has cooled, reweigh the crucible with its lid and contents. Record the mass.
- Calculate and record the mass of residue obtained.

Results

I	
II	
III	
IV	
V	

[5]

(b) Calculate the amount, in mol, of water lost.

amount of H_2O = ... mol

Hence calculate the relative formula mass, M_r, of $\mathbf{MA_2}$.

M_r of $\mathbf{MA_2}$ = ...

[2]

(c) **FB 5** is a solution of the hydrated salt $\mathbf{MA}_2$. The $\mathbf{A}^-$ ion is a halide.
Carry out tests to identify the halide present in $\mathbf{MA}_2$.
Record the reagents used, the results of your tests and the identity of $\mathbf{A}^-$.

$\mathbf{A}^-$ is ..... [2]

(d) Using your answers to **(b)** and **(c)**, identify the ion $\mathbf{M}^{2+}$.

$\mathbf{M}^{2+}$ is ..... [1]

(e) A student correctly identifies $\mathbf{A}^-$ but did not heat the sample of **FB 4** for long enough to remove all the water of crystallisation.
Despite this error, the student still correctly identifies $\mathbf{M}^{2+}$.

Explain how the student's answer in **(b)** would differ from the true answer.

.....

.....

Explain why the student still correctly identifies $\mathbf{M}^{2+}$.

.....

.....
[2]

[Total: 12]

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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) **FB 6** is potassium manganate(VII). Place all the **FB 6** in a hard-glass test-tube and heat gently at first and then more strongly.
Record your observations.

.....

.....

..... [1]

Leave the tube to cool and keep for use in (a)(ii).
While the tube is cooling, you may wish to begin work on (b).

(ii) Complete Table 3.1 by carrying out the tests described.
Record your observations.

Table 3.1

test	*observations*
Test 1 To a 7 cm depth of distilled water in a boiling tube, add approximately half of the residue from **(a)(i)**.	
Test 2 To a 4 cm depth of aqueous sodium hydroxide in a test-tube, add the remaining residue from **(a)(i)**.	

[2]

(iii) Suggest what type of reaction takes place in **(a)(i)**.

..... [1]

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(b) **FB 7** is a solution of a salt which contains a cation and an anion from those listed in the Qualitative analysis notes.
FB 8 is 0.100 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.

(i) Complete Table 3.2 by carrying out the tests described. Record your observations.

Table 3.2

test	*observations*
Test 1 To a 1 cm depth of **FB 7** in a test-tube, add aqueous ammonia until there is no further change, then	
add a few drops of hydrogen peroxide.	
Test 2 To a 1 cm depth of **FB 7** in a test-tube, add a 1 cm depth of aqueous potassium iodide, then	
add **FB 8**.	

[5]

(ii) The anion in **FB 7** is either the sulfite ion or the sulfate ion.
Carry out tests to identify which ion is present.
Record the reagents used and the results of your tests.

[2]

(iii) Give the formula of the salt in **FB 7**.

.....

[1]

[Total: 12]

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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^+

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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	$V_m = 22.4\,dm^3\,mol^{-1}$ 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	$c = 4.18\,kJ\,kg^{-1}\,K^{-1}$ ($4.18\,J\,g^{-1}\,K^{-1}$)

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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 –

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