Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME										
CENTRE NUMBER						CANDIDATE NUMBER				

8525454663

CHEMISTRY **9701/36**

Paper 3 Advanced Practical Skills 2 **October/November 2023**

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. Any blank pages are indicated.

DC (PQ) 311011/3

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 When hydrogen peroxide is decomposed by a suitable catalyst, oxygen and water are produced. You will determine the concentration of a solution of hydrogen peroxide by decomposing it and measuring the mass of oxygen produced.

FB 1 is aqueous hydrogen peroxide, H_2O_2.
FB 2 is the catalyst, manganese(IV) oxide, MnO_2.

(a) Method

- Use the measuring cylinder to transfer 25.0 cm^3 of **FB 1** into a conical flask.
- Weigh the conical flask containing **FB 1**. Record the mass.
- Weigh the container with **FB 2**. Record the mass.
- Tip all the **FB 2** into the conical flask. Swirl the flask gently.
- Weigh the container with any residual **FB 2**. Record the mass.
- Calculate the mass of **FB 2** added. Record the mass.
- Leave the conical flask and its contents to stand for 30 minutes. Swirl the flask occasionally.

While the reaction is taking place, begin work on Question 2 or Question 3.

- When the reaction is complete, weigh the flask and its contents. Record the mass.

You will use FB 1 in Questions 2 and 3.

I	
II	
III	

[3]

(b) Calculations

(i) Calculate the mass of oxygen liberated.

mass of oxygen = ... g [1]

(ii) Give the equation for the decomposition of hydrogen peroxide in **(a)**. Include state symbols.

.... [1]

(iii) Calculate the concentration, in $mol\,dm^{-3}$, of hydrogen peroxide in **FB 1**.

concentration of H_2O_2 in **FB 1** = ... $mol\,dm^{-3}$ [2]

(iv) The "**volume strength**" of hydrogen peroxide is equal to the volume of oxygen, in dm^3, produced at room conditions, when $1.00\,dm^3$ of a solution of hydrogen peroxide is completely catalytically decomposed.

Use your answer in **(b)(iii)** to calculate the volume, in dm^3, of oxygen produced when $1.00\,dm^3$ of **FB 1** decomposes at room conditions. Your answer to this calculation is numerically equal to the "volume strength", in vol, of solution **FB 1**. Show your working.

"volume strength" of H_2O_2 in **FB 1** = ... vol [1]

(c) **(i)** Describe the observation to determine whether or not the decomposition of hydrogen peroxide in **FB 1** is complete.
Explain your answer.

....

....

.... [1]

(ii) A student suggests that the experiment in **(a)** would be more accurate if a loose-fitting plug of cotton wool was pushed gently into the mouth of the conical flask during the reaction.
State whether the student is correct. Explain your answer.

....

....

.... [2]

(iii) Deduce the mass of manganese(IV) oxide, **FB 2**, left in the conical flask at the end of the experiment. Explain your answer.

....

.... [1]

[Total: 12]

2 The concentration of a solution of hydrogen peroxide can also be determined by titration with acidified potassium manganate(VII). The equation for the reaction is shown below.

$$2MnO_4^-(aq) + 5H_2O_2(aq) + 6H^+(aq) \rightarrow 2Mn^{2+}(aq) + 5O_2(g) + 8H_2O(l)$$

FB 1 is aqueous hydrogen peroxide, H_2O_2.
FB 3 is 0.0180 mol dm^{-3} potassium manganate(VII), $KMnO_4$.
FB 4 is dilute sulfuric acid, H_2SO_4.

(a) Method

Dilution of FB 1

- Pipette 10.0 cm^3 of **FB 1** into the 250 cm^3 volumetric flask.
- Make the solution up to the mark using distilled water.
- Shake the flask thoroughly.
- This diluted solution of hydrogen peroxide is **FB 5**.

Titration

- Fill the burette with **FB 3**.
- Pipette 25.0 cm^3 of **FB 5** into a clean conical flask.
- Rinse out the measuring cylinder with distilled water. Use the measuring cylinder to transfer 20 cm^3 of **FB 4** into the same 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 use in your calculations. Show clearly how you obtained the mean value.

25.0 cm^3 of **FB 5** required .... cm^3 of **FB 3**. [1]

(c) Calculations

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

(ii) Calculate the amount, in mol, of potassium manganate(VII) present in the volume of **FB 3** calculated in **(b)**.

amount of $KMnO_4$ = ... mol [1]

(iii) Use your answer to **(c)(ii)** and the equation on page 4 to calculate the amount, in mol, of hydrogen peroxide in **FB 5** used in each titration.

amount of H_2O_2 = ... mol [1]

(iv) Calculate the concentration of hydrogen peroxide in **FB 1**, in $mol\,dm^{-3}$.

concentration of H_2O_2 in **FB 1** = ... $mol\,dm^{-3}$ [1]

(d) **(i)** State which procedure, the method you used in **1(a)** or the method you used in **2(a)**, gives a more accurate value for the concentration of H_2O_2 in **FB 1**.
Explain your answer.

....

....

.... [1]

(ii) The uncertainty in reading a 25 cm^3 pipette is ±0.06 cm^3.
Explain why this pipette is more accurate than a burette for measuring 25.0 cm^3 of a solution.

....

....

.... [1]

[Total: 14]

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 **(a)** **FB 6** is a solution containing one cation and one anion. The anion is listed in the Qualitative analysis notes.
FB 7 is aqueous sodium thiosulfate, $Na_2S_2O_3$.

(i) To a 1 cm depth of **FB 7** in a test-tube, add an equal volume of **FB 6**.
Record the first change you observe.
Wash out your test-tube with plenty of tap water as soon as you finish this test.

....

.... [1]

(ii) Carry out tests to identify the anion in **FB 6**. The anion does **not** contain carbon or sulfur.
Record details of your tests and all your observations in a suitable form below.

[3]

(iii) Give the formula of **FB 6**.

FB 6 is .... [1]

(b) **FB 8** is a solution containing one cation and one anion, both of which are listed in the Qualitative analysis notes.
FB 1 is aqueous hydrogen peroxide.

(i) Use a 1 cm depth of **FB 8** for the following tests. Record your observations in Table 3.1.

Table 3.1

test	*observation*
Test 1 Add aqueous ammonia.	
Test 2 Add aqueous barium nitrate or aqueous barium chloride, then	
add dilute hydrochloric acid.	
Test 3 Add an equal volume of **FB 1**, then	
add aqueous sodium hydroxide.	
Test 4 Add a few drops of acidified aqueous potassium manganate(VII).	

[5]

(ii) Give the ionic equation for the reaction of **FB 8** in **Test 1**. Include state symbols.

.... [2]

(iii) **Test 3** involves a redox reaction.
Using your observations, justify the statement that a redox reaction has taken place.

....

....

....

.... [2]

[Total: 14]

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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	$L = 6.022 \times 10^{23}\,mol^{-1}$
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 –