Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

7099515952

CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **October/November 2019**

2 hours

Candidates answer on the Question Paper.

Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your centre number, candidate number and name on all the work you hand in.
Give details of the practical session and laboratory where appropriate, in the boxes provided.
Write in dark blue or black pen.
You may use an HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.
Electronic calculators may be used.
You may lose marks if you do not show your working or if you do not use appropriate units.
Use of a Data Booklet is unnecessary.

Qualitative Analysis Notes are printed on pages 10 and 11.
A copy of the Periodic Table is printed on page 12.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

Session
Laboratory

For Examiner's Use	
1	
2	
3	
Total	

This document consists of **12** printed pages.

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Cambridge Assessment International Education

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 your working and appropriate significant figures in the final answer to **each** step of your calculations.

1 Hydrogen peroxide decomposes in a reaction catalysed by manganese(IV) oxide.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

You will investigate this decomposition by measuring the volume of oxygen collected over a period of time. You will also use the volume of oxygen collected to calculate the concentration of the aqueous hydrogen peroxide.

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

(a) Method

- Fill the tub with water to a depth of approximately 5 cm.
- Fill the 250 cm^3 measuring cylinder **completely** with water. Hold a piece of paper towel firmly over the top, invert the measuring cylinder and place it in the water in the tub.
- Remove the paper towel and clamp the inverted measuring cylinder so that the open end is in the water just above the base of the tub.
- Use the 50 cm^3 measuring cylinder to place 30 cm^3 of **FB 1** and 20 cm^3 of distilled water into the reaction flask labelled **X**.
- Check that the bung fits tightly into the neck of flask **X**, clamp flask **X** and place the end of the delivery tube into the 250 cm^3 measuring cylinder.
- Remove the bung from the neck of flask **X**. Add all of the **FB 2** into the hydrogen peroxide in the flask and replace the bung **immediately**. Start the stop-clock and leave it running until the end of the experiment.
- Remove the flask from the clamp and swirl to mix the contents, then replace the flask in the clamp.
- After 1 minute measure the volume of gas collected.
- After 4 minutes from the start of the experiment measure the volume of gas collected.

Keep FB 1 for use in Question 3.

Results

[3]

(b) Calculation

(i) Use the volume of gas that you collected at 4 minutes to calculate the number of moles of hydrogen peroxide which had decomposed at this time.
(Assume 1 mol of gas occupies 24.0 dm^3 at this temperature.)

moles of H_2O_2 = ... mol [1]

(ii) Assume all the H_2O_2 had decomposed in 4 minutes.

Calculate the initial concentration of H_2O_2, in mol dm^3, in **FB 1**.

initial concentration of H_2O_2 = ... mol dm^{-3} [2]

(c) A student missed taking a reading at 1 minute so took a reading at 2 minutes instead. This student stated that after 2 minutes:

$$\text{rate of reaction} = \left(\frac{\text{volume of gas collected}}{2}\right) \text{cm}^3\ \text{minute}^{-1}$$

Is the student correct? Explain your answer.

....

....

....

.... [2]

(d) Another student carried out the experiment in **(a)** but used twice the mass of manganese(IV) oxide.

State and explain what effect this would have on the results obtained.

....

.... [1]

[Total: 9]

2 In **Question 1** you determined the concentration of a sample of aqueous hydrogen peroxide, **FB 1**, by measuring the volume of oxygen produced when it decomposed.

In **Question 2** you will determine the concentration of a different sample of aqueous hydrogen peroxide by titration with acidified manganate(VII) ions. The equation for the reaction is shown.

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

FB 3 is aqueous hydrogen peroxide, H_2O_2.
FB 4 is 0.0200 mol dm^{-3} potassium manganate(VII), $KMnO_4$.
FB 5 is 1 mol dm^{-3} sulfuric acid, H_2SO_4.

(a) Method

- Fill the burette with **FB 4**.
- Pipette 25.0 cm^3 of **FB 3** into a conical flask.
- Rinse the 50 cm^3 measuring cylinder with distilled water.
- Use this measuring cylinder to add 20 cm^3 of **FB 5** into 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 certain any recorded results show the precision of your practical work.
- Record, in a suitable form below, all of your burette readings and the volume of **FB 4** added in each accurate titration.

Keep FB 4 for use in Question 3.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a suitable value for the volume of **FB 4** to be used in your calculations. Show clearly how you obtained this value.

25.0 cm^3 of **FB 3** required .... cm^3 of **FB 4**. [1]

(c) Calculations

(i) Calculate the number of moles of manganate(VII) ions present in the volume of **FB 4** recorded in **(b)**.

moles of MnO_4^- = ... mol [1]

(ii) Use your answer to **(c)(i)** and the equation on page **4** to determine the number of moles of hydrogen peroxide present in 25.0 cm^3 of **FB 3**.

moles of H_2O_2 = ... mol [1]

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

concentration of H_2O_2 = ... mol dm^{-3} [1]

(d) In **Question 1** and in **Question 2** you determined the concentration of aqueous hydrogen peroxide using different methods. The method used in **Question 2** is the more accurate.

Identify **two** sources of error in the determination of the concentration in **Question 1** and suggest how these errors could be minimised.

error 1 ....

minimised by ....

error 2 ....

minimised by ....
[2]

(e) A student suggested one source of error in the method used in **Question 2** was that the sulfuric acid was measured using a measuring cylinder and that a pipette should be used.

Explain whether this suggestion is correct.

....

.... [1]

(f) **(i)** Another student was given a sample of aqueous hydrogen peroxide that was labelled as '10 vol'.
The theoretical concentration of this sample of H_2O_2(aq) is 0.833 mol dm^{-3}.
The student used a titration method to find the actual concentration of this sample and found it to be 0.796 mol dm^{-3}.

Calculate the percentage difference, based on the theoretical concentration, between the actual and theoretical concentrations.

percentage difference = ... % [1]

(ii) When determining the concentration of hydrogen peroxide in a school or college laboratory, the value is nearly always much lower than the theoretical value.

Suggest a reason for this difference.

....

.... [1]

[Total:16]

Qualitative Analysis

Where reagents are selected for use in a test, the **name** or **correct formula** of the element or compound must be given.

At each stage of any test you are to record details of the following:

- colour changes seen;
- the formation of any precipitate and its solubility in an excess of the reagent added;
- the formation of any gas and its identification by a suitable test.

You should indicate clearly at what stage in a test a change occurs.

If any solution is warmed, a **boiling tube** must be used.

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

No additional tests for ions present should be attempted.

3 **(a)** **(i)** **FB 6**, **FB 7** and **FB 8** are all aqueous solutions. Each contains one anion and one cation.

Carry out the following tests and record your observations.

test	*observations*		
	FB 6	**FB 7**	**FB 8**
To a 1 cm depth in a test-tube add a 1 cm depth of dilute sulfuric acid and then add a few drops of **FB 4**, $KMnO_4$(aq).			
To a 1 cm depth in a boiling tube add aqueous sodium hydroxide, then			
warm gently.			
To a 1 cm depth in a test-tube add a 1 cm depth of **FB 1**, H_2O_2(aq), and then add aqueous sodium hydroxide.			
To a 1 cm depth in a test-tube add aqueous barium chloride or aqueous barium nitrate.			
To a 1 cm depth in a boiling tube add a 1 cm depth of aqueous sodium hydroxide and a piece of aluminium foil and then warm gently.			

[8]

(ii) Identify, with a reason, the cation present in **FB 6**.

....

.... [1]

(iii) Identify, with a reason, **two** anions that **could** be present in **FB 6**.

....

.... [1]

(iv) Identify, with a reason, a cation that could **not** be present in **FB 7**.

....

.... [1]

(v) Identify, with a reason, an anion that could be present in **FB 8**.

....

.... [1]

(b) A student is given an unlabelled bottle containing a liquid that is either propan-1-ol, $CH_3CH_2CH_2OH$, or ethanoic acid, CH_3COOH.

Describe tests that would allow the student to confirm the identity of the liquid. Record in a suitable table the tests and the expected positive result for each of your tests.

[3]

[Total: 15]

Qualitative Analysis Notes

1 Reactions of aqueous cations

ion	*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 heating	–
barium, Ba^{2+}(aq)	faint white ppt. is nearly always observed unless reagents are pure	no ppt.
calcium, Ca^{2+}(aq)	white ppt. with high [Ca^{2+}(aq)]	no ppt.
chromium(III), Cr^{3+}(aq)	grey-green ppt. soluble in excess	grey-green ppt. insoluble in excess
copper(II), Cu^{2+}(aq)	pale blue ppt. insoluble in excess	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

ion	*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 ppt. with Ag^+(aq) (partially soluble in NH_3(aq))
iodide, I^-(aq)	gives 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
sulfate, SO_4^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (insoluble in excess dilute strong acids)
sulfite, SO_3^{2-}(aq)	gives white ppt. with Ba^{2+}(aq) (soluble in excess dilute strong acids)

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 (ppt. dissolves with excess CO_2)
chlorine, Cl_2	bleaches damp litmus paper
hydrogen, H_2	‘pops’ with a lighted splint
oxygen, O_2	relights a glowing splint

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 –		114 Fl flerovium –		116 Lv livermorium –		

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 –