

Cambridge  
International  
AS & A Level

**Cambridge International Examinations**  
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE  
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CENTRE  
NUMBER

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NUMBER

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**CHEMISTRY**

**9701/33**

Paper 3 Advanced Practical Skills 1

**February/March 2017**

**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.

<b>Session</b>	
<b>Laboratory</b>	

<b>For Examiner's Use</b>	
<b>1</b>	
<b>2</b>	
<b>3</b>	
<b>Total</b>	

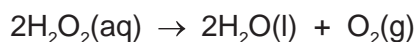
This document consists of **12** printed pages.



## 2

- 1 The concentration of hydrogen peroxide may be given in  $\text{mol dm}^{-3}$  or as 'volume strength'. You will determine the concentration of hydrogen peroxide in  $\text{mol dm}^{-3}$  and in 'volume strength' by a gas collection method.

Hydrogen peroxide decomposes to form water and oxygen. The reaction is much faster in the presence of a catalyst such as manganese(IV) oxide.



'Volume strength' is defined as the volume of oxygen in  $\text{cm}^3$  produced from the decomposition of  $1.0\text{cm}^3$  of hydrogen peroxide at room temperature and pressure. For example,  $1.0\text{cm}^3$  of '100 volume' hydrogen peroxide will produce  $100\text{cm}^3$  of oxygen.

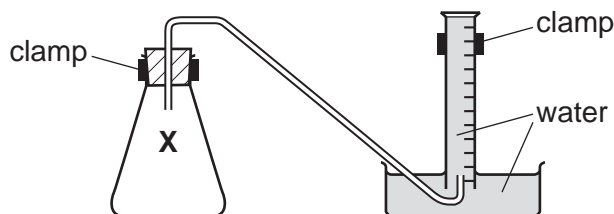
**FA 1** is a solution of hydrogen peroxide,  $\text{H}_2\text{O}_2$ .

**FA 2** is manganese(IV) oxide,  $\text{MnO}_2$ .

**(a) Method**

**Read the whole method before starting any practical work.**

The diagram below may help you in setting up your apparatus.



- Fill the tub with water to a depth of about 5 cm.
- Fill the  $250\text{cm}^3$  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.
- Rinse the  $50\text{cm}^3$  measuring cylinder with a little **FA 1** then use it to transfer  $150\text{cm}^3$  of **FA 1** into the reaction flask labelled **X**.
- Check that the bung fits tightly in the neck of flask **X**, clamp flask **X** and place the end of the delivery tube into the inverted  $250\text{cm}^3$  measuring cylinder.
- Remove the bung from the neck of the flask. Tip **FA 2** into the hydrogen peroxide and replace the bung **immediately**. Remove the flask from the clamp and swirl it to mix the contents. Swirl the flask occasionally until no more gas is given off. Replace the flask in the clamp.
- Measure and record the final volume of gas in the measuring cylinder in the space below.

**Keep FA 1 for use in Question 2.**

**Result**

[2]

**(b) Calculations**

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

- (i) Use the information on page 2 to calculate the 'volume strength' of **FA 1**.

'volume strength' of **FA 1** = .....

- (ii) Calculate the number of moles of oxygen collected in the measuring cylinder.  
[Assume 1 mole of gas occupies 24.0 dm<sup>3</sup> under these conditions.]

moles of O<sub>2</sub> = ..... mol

- (iii) Using your answer to (ii) calculate the number of moles of hydrogen peroxide in the volume of **FA 1** added to flask **X**.

moles of H<sub>2</sub>O<sub>2</sub> = ..... mol

- (iv) Calculate the concentration of hydrogen peroxide, **FA 1**, in mol dm<sup>-3</sup>.

concentration of H<sub>2</sub>O<sub>2</sub>, **FA 1** = ..... mol dm<sup>-3</sup>  
[4]

- (c) (i)** A source of error in this experiment is that some oxygen escapes before the bung can be inserted.

Suggest a change to the practical procedure given in **(a)** to reduce this source of error. You may draw a diagram as part of your answer.

.....

.....

- (ii)** The error in reading a 50 cm<sup>3</sup> measuring cylinder is  $\pm 0.5$  cm<sup>3</sup>.

Calculate the maximum percentage error in the volume of hydrogen peroxide added to flask **X** in **(a)**.

maximum percentage error in volume of H<sub>2</sub>O<sub>2</sub> = ..... %

- (iii)** Explain why the presence of 20 cm<sup>3</sup> of air in the 250 cm<sup>3</sup> measuring cylinder before the start of the experiment would decrease the accuracy of the results obtained in **(a)**.

.....

.....

.....

[4]

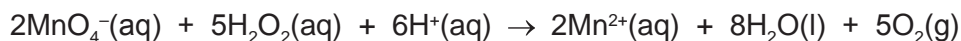
- (d)** If you repeated the method described using half the mass of **FA 2**, what volume of gas would you expect to collect? Explain your answer.

.....

..... [1]

[Total: 11]

- 2 You will carry out a second experiment to determine the concentration of hydrogen peroxide, **FA 1**, in  $\text{mol dm}^{-3}$ , by titration with acidified aqueous potassium manganate(VII). The equation for the reaction is given below.



**FA 1** is a solution of hydrogen peroxide,  $\text{H}_2\text{O}_2$ .

**FA 3** is  $0.0300 \text{ mol dm}^{-3}$  potassium manganate(VII),  $\text{KMnO}_4$ .

**FA 4** is dilute sulfuric acid.

**(a) Method**

- Fill the burette with **FA 3**.
- Pipette  $25.0 \text{ cm}^3$  of **FA 1** into a conical flask.
- Use the  $25 \text{ cm}^3$  measuring cylinder to add approximately  $20 \text{ cm}^3$  of **FA 4** to the conical flask.
- Perform a rough titration and record your burette readings in the space below.

The rough titre is .....  $\text{cm}^3$ .

- 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 **FA 3** added in each accurate titration.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

- (b)** From your accurate titration results, obtain a suitable value for the volume of **FA 3** to be used in your calculations. Show clearly how you obtained this value.

$25.0 \text{ cm}^3$  of **FA 1** required .....  $\text{cm}^3$  of **FA 3**. [1]

**(c) Calculations**

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

- (i)** Calculate the number of moles of manganate(VII) ions present in the volume of **FA 3** calculated in **(b)**.

moles of  $\text{MnO}_4^-$  = ..... mol

- (ii)** Calculate the number of moles of hydrogen peroxide present in  $25.0 \text{ cm}^3$  of **FA 1**.

moles of  $\text{H}_2\text{O}_2$  = ..... mol

- (iii)** Using your answer to **(ii)** calculate the concentration, in  $\text{mol dm}^{-3}$ , of hydrogen peroxide in **FA 1**.

concentration of  $\text{H}_2\text{O}_2$  in **FA 1** = .....  $\text{mol dm}^{-3}$   
[4]

[Total: 12]

### 3 Qualitative Analysis

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

- colour changes seen
- the formation of any precipitate
- the solubility of such precipitates in an excess of the reagent added

Where gases are released they should be identified by a test, **described in the appropriate place in your observations.**

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

**No additional tests for ions present should be attempted.**

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

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

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

(a) **FA 5**, **FA 6** and **FA 7** are solutions, **some** of which contain ions that are listed on pages 10 and 11.

test	observations		
	FA 5	FA 6	FA 7
(i) To a 0.5cm depth of solution in a boiling tube add aqueous sodium hydroxide, then			
warm gently.			
Allow to cool, add a piece of aluminium foil and warm again.		X	
(ii) To a 1 cm depth of solution in a test-tube add two or three drops of acidified aqueous potassium manganate(VII). (Do <b>not</b> use <b>FA 3</b> .)			
If no reaction occurs, pour the mixture into a boiling tube and warm gently.			
(iii) To a 1 cm depth of solution in a test-tube add a 2 cm depth of '10 volume' hydrogen peroxide and leave to stand. (Do <b>not</b> use <b>FA 1</b> .)	X		
(iv) To a 1 cm depth of solution in a test-tube add a 1 cm depth of dilute hydrochloric acid, then	X		
add a 1 cm depth of aqueous barium chloride or aqueous barium nitrate.	X		

[11]



- (b) (i) Identify as many ions present in **FA 5**, **FA 6** and **FA 7** as possible from your observations. If an ion cannot be identified from the tests, write 'unknown' in the space.

	cation(s)	anion(s)
<b>FA 5</b>		
<b>FA 6</b>		
<b>FA 7</b>		

- (ii) Describe another test you could carry out to confirm the identity of a cation you have identified in (i). Record the reagent(s) and expected observation(s) in the space below. **Do not carry out this test.**

- (iii) Write an ionic equation for the reaction that would occur in (ii). Include state symbols.

.....

[6]

[Total:17]

## Qualitative Analysis Notes

## 1 Reactions of aqueous cations

ion	reaction with	
	NaOH(aq)	NH <sub>3</sub> (aq)
aluminium, Al <sup>3+</sup> (aq)	white ppt. soluble in excess	white ppt. insoluble in excess
ammonium, NH <sub>4</sub> <sup>+</sup> (aq)	no ppt. ammonia produced on heating	–
barium, Ba <sup>2+</sup> (aq)	faint white ppt. is nearly always observed unless reagents are pure	no ppt.
calcium, Ca <sup>2+</sup> (aq)	white ppt. with high [Ca <sup>2+</sup> (aq)]	no ppt.
chromium(III), Cr <sup>3+</sup> (aq)	grey-green ppt. soluble in excess	grey-green ppt. insoluble in excess
copper(II), Cu <sup>2+</sup> (aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution
iron(II), Fe <sup>2+</sup> (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 <sup>3+</sup> (aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess
magnesium, Mg <sup>2+</sup> (aq)	white ppt. insoluble in excess	white ppt. insoluble in excess
manganese(II), Mn <sup>2+</sup> (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 <sup>2+</sup> (aq)	white ppt. soluble in excess	white ppt. soluble in excess

## 2 Reactions of anions

<i>ion</i>	<i>reaction</i>
carbonate, $\text{CO}_3^{2-}$	$\text{CO}_2$ liberated by dilute acids
chloride, $\text{Cl}^-(\text{aq})$	gives white ppt. with $\text{Ag}^+(\text{aq})$ (soluble in $\text{NH}_3(\text{aq})$ )
bromide, $\text{Br}^-(\text{aq})$	gives cream ppt. with $\text{Ag}^+(\text{aq})$ (partially soluble in $\text{NH}_3(\text{aq})$ )
iodide, $\text{I}^-(\text{aq})$	gives yellow ppt. with $\text{Ag}^+(\text{aq})$ (insoluble in $\text{NH}_3(\text{aq})$ )
nitrate, $\text{NO}_3^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil
nitrite, $\text{NO}_2^-(\text{aq})$	$\text{NH}_3$ liberated on heating with $\text{OH}^-(\text{aq})$ and $\text{Al}$ foil; $\text{NO}$ liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown $\text{NO}_2$ in air)
sulfate, $\text{SO}_4^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (insoluble in excess dilute strong acids)
sulfite, $\text{SO}_3^{2-}(\text{aq})$	gives white ppt. with $\text{Ba}^{2+}(\text{aq})$ (soluble in excess dilute strong acids)

## 3 Tests for gases

<i>gas</i>	<i>test and test result</i>
ammonia, $\text{NH}_3$	turns damp red litmus paper blue
carbon dioxide, $\text{CO}_2$	gives a white ppt. with limewater (ppt. dissolves with excess $\text{CO}_2$ )
chlorine, $\text{Cl}_2$	bleaches damp litmus paper
hydrogen, $\text{H}_2$	'pops' with a lighted splint
oxygen, $\text{O}_2$	relights a glowing splint

The Periodic Table of Elements

		Group																																	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18																		
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">1 H hydrogen 1.0</div> <div style="border: 1px solid black; padding: 2px;"> <b>Key</b>                      atomic number                      atomic symbol                      name                      relative atomic mass                 </div> </div>																																	
3 Li lithium 6.9	4 Be beryllium 9.0	11 Na sodium 23.0	12 Mg magnesium 24.3	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 oganeson —																		

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 —