

CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
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.

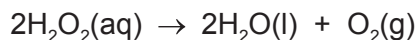
Session	
Laboratory	

For Examiner's Use	
1	
2	
3	
Total	

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

- 1 The concentration of hydrogen peroxide may be given in mol dm^{-3} or as 'volume strength'. You will determine the concentration of hydrogen peroxide in 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 cm^3 produced from the decomposition of 1.0cm^3 of hydrogen peroxide at room temperature and pressure. For example, 1.0cm^3 of '100 volume' hydrogen peroxide will produce 100cm^3 of oxygen.

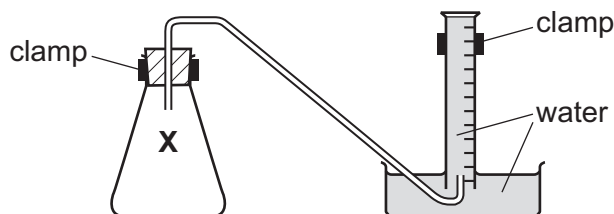
FA 1 is a solution of hydrogen peroxide, H_2O_2 .

FA 2 is manganese(IV) oxide, 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 250cm^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 50cm^3 measuring cylinder with a little **FA 1** then use it to transfer 150cm^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 250cm^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 dm³ under these conditions.]

moles of O₂ = 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 H₂O₂ = mol

- (iv) Calculate the concentration of hydrogen peroxide, **FA 1**, in mol dm⁻³.

concentration of H₂O₂, **FA 1** = mol dm⁻³
[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 cm³ measuring cylinder is ±0.5 cm³.

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

maximum percentage error in volume of H₂O₂ = %

- (iii) Explain why the presence of 20 cm³ of air in the 250 cm³ measuring cylinder before the start of the experiment would decrease the accuracy of the results obtained in (a).

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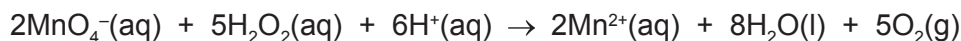
[4]

- (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 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, H_2O_2 .

FA 3 is $0.0300 \text{ mol dm}^{-3}$ potassium manganate(VII), KMnO_4 .

FA 4 is dilute sulfuric acid.

(a) Method

- Fill the burette with **FA 3**.
- Pipette 25.0 cm^3 of **FA 1** into a conical flask.
- Use the 25 cm^3 measuring cylinder to add approximately 20 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 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 cm^3 of **FA 1** required 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 MnO_4^- = mol

- (ii) Calculate the number of moles of hydrogen peroxide present in 25.0 cm³ of **FA 1**.

moles of H_2O_2 = mol

- (iii) Using your answer to (ii) calculate the concentration, in mol dm⁻³, of hydrogen peroxide in **FA 1**.

concentration of H_2O_2 in **FA 1** = 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 not use FA 3 .)			
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 not use FA 1 .)	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)
FA 5		
FA 6		
FA 7		

- (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

<i>ion</i>	<i>reaction with</i>	
	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

<i>ion</i>	<i>reaction</i>
carbonate, CO_3^{2-}	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, $\text{NO}_3^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil
nitrite, $\text{NO}_2^-(\text{aq})$	NH_3 liberated on heating with $\text{OH}^-(\text{aq})$ and Al foil; NO liberated by dilute acids (colourless $\text{NO} \rightarrow$ (pale) brown 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, 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

		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;">2 He helium 4.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">3 Li lithium 6.9</div> <div style="border: 1px solid black; padding: 2px;">4 Be beryllium 9.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">5 B boron 10.8</div> <div style="border: 1px solid black; padding: 2px;">6 C carbon 12.0</div> <div style="border: 1px solid black; padding: 2px;">7 N nitrogen 14.0</div> <div style="border: 1px solid black; padding: 2px;">8 O oxygen 16.0</div> <div style="border: 1px solid black; padding: 2px;">9 F fluorine 19.0</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">11 Na sodium 23.0</div> <div style="border: 1px solid black; padding: 2px;">12 Mg magnesium 24.3</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">13 Al aluminium 27.0</div> <div style="border: 1px solid black; padding: 2px;">14 Si silicon 28.1</div> <div style="border: 1px solid black; padding: 2px;">15 P phosphorus 31.0</div> <div style="border: 1px solid black; padding: 2px;">16 S sulfur 32.1</div> <div style="border: 1px solid black; padding: 2px;">17 Cl chlorine 35.5</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">19 K potassium 39.1</div> <div style="border: 1px solid black; padding: 2px;">20 Ca calcium 40.1</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">21 Sc scandium 45.0</div> <div style="border: 1px solid black; padding: 2px;">22 Ti titanium 47.9</div> <div style="border: 1px solid black; padding: 2px;">23 V vanadium 50.9</div> <div style="border: 1px solid black; padding: 2px;">24 Cr chromium 52.0</div> <div style="border: 1px solid black; padding: 2px;">25 Mn manganese 54.9</div> <div style="border: 1px solid black; padding: 2px;">26 Fe iron 55.8</div> <div style="border: 1px solid black; padding: 2px;">27 Co cobalt 58.9</div> <div style="border: 1px solid black; padding: 2px;">28 Ni nickel 58.7</div> <div style="border: 1px solid black; padding: 2px;">29 Cu copper 63.5</div> <div style="border: 1px solid black; padding: 2px;">30 Zn zinc 65.4</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">37 Rb rubidium 85.5</div> <div style="border: 1px solid black; padding: 2px;">38 Sr strontium 87.6</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">39 Y yttrium 88.9</div> <div style="border: 1px solid black; padding: 2px;">40 Zr zirconium 91.2</div> <div style="border: 1px solid black; padding: 2px;">41 Nb niobium 92.9</div> <div style="border: 1px solid black; padding: 2px;">42 Mo molybdenum 95.9</div> <div style="border: 1px solid black; padding: 2px;">43 Tc technetium —</div> <div style="border: 1px solid black; padding: 2px;">44 Ru ruthenium 101.1</div> <div style="border: 1px solid black; padding: 2px;">45 Rh rhodium 102.9</div> <div style="border: 1px solid black; padding: 2px;">46 Pd palladium 106.4</div> <div style="border: 1px solid black; padding: 2px;">47 Ag silver 107.9</div> <div style="border: 1px solid black; padding: 2px;">48 Cd cadmium 112.4</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">55 Cs caesium 132.9</div> <div style="border: 1px solid black; padding: 2px;">56 Ba barium 137.3</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">57–71 lanthanoids</div> <div style="border: 1px solid black; padding: 2px;">72 Hf hafnium 178.5</div> <div style="border: 1px solid black; padding: 2px;">73 Ta tantalum 180.9</div> <div style="border: 1px solid black; padding: 2px;">74 W tungsten 183.8</div> <div style="border: 1px solid black; padding: 2px;">75 Re rhenium 186.2</div> <div style="border: 1px solid black; padding: 2px;">76 Os osmium 190.2</div> <div style="border: 1px solid black; padding: 2px;">77 Ir iridium 192.2</div> <div style="border: 1px solid black; padding: 2px;">78 Pt platinum 195.1</div> <div style="border: 1px solid black; padding: 2px;">79 Au gold 197.0</div> <div style="border: 1px solid black; padding: 2px;">80 Hg mercury 200.6</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">87 Fr francium —</div> <div style="border: 1px solid black; padding: 2px;">88 Ra radium —</div> </div>															
		<div style="display: flex; justify-content: space-between; align-items: center;"> <div style="border: 1px solid black; padding: 2px;">89–103 actinoids</div> <div style="border: 1px solid black; padding: 2px;">104 Rf rutherfordium —</div> <div style="border: 1px solid black; padding: 2px;">105 Db dubnium —</div> <div style="border: 1px solid black; padding: 2px;">106 Sg seaborgium —</div> <div style="border: 1px solid black; padding: 2px;">107 Bh bohrium —</div> <div style="border: 1px solid black; padding: 2px;">108 Hs hassium —</div> <div style="border: 1px solid black; padding: 2px;">109 Mt meitnerium —</div> <div style="border: 1px solid black; padding: 2px;">110 Ds darmstadtium —</div> <div style="border: 1px solid black; padding: 2px;">111 Rg roentgenium —</div> <div style="border: 1px solid black; padding: 2px;">112 Cn copernicium —</div> </div>															

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
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 —

lanthanoids

actinoids