Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME	

CENTRE NUMBER						CANDIDATE NUMBER				

0417493788

CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **February/March 2020**

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, use appropriate units and use an appropriate number of significant figures.
- Give details of the practical session and laboratory, where appropriate, in the boxes provided.

Session
Laboratory

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.
- Notes for use in qualitative analysis are provided in the question paper.

For Examiner's Use	
1	
2	
3	
Total	

This document has **12** pages. Blank pages are indicated.

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 The concentrations of solutions of hydrogen peroxide are often represented in terms of 'volume strength'. In this experiment you will determine the 'volume strength' of a solution of hydrogen peroxide by titration with acidified potassium manganate(VII).

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

FA 1 is 0.0300 mol dm^{-3} potassium manganate(VII), $KMnO_4$.
FA 2 is dilute sulfuric acid, H_2SO_4.
FA 3 is aqueous hydrogen peroxide, H_2O_2.

(a) Method

Dilution of FA 3

- Pipette 25.0 cm^3 of **FA 3** into the 250 cm^3 volumetric flask.
- Make the solution up to the mark using distilled water.
- Shake the flask thoroughly.
- Label this diluted solution of hydrogen peroxide **FA 4**.

Titration

- Fill the burette with **FA 1**.
- Rinse the pipette thoroughly with distilled water and then with a little **FA 4**.
- Pipette 25.0 cm^3 of **FA 4** into a conical flask.
- Use the 25 cm^3 measuring cylinder to add 20 cm^3 of **FA 2** into the same 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 sure any recorded results show the precision of your practical work.
- Record **all** of your burette readings and the volume of **FA 1** added in each accurate titration.

Keep FA 1, FA 2 and FA 3 for use in Questions 2 and 3.

I	
II	
III	
IV	
V	
VI	
VII	

[7]

(b) From your accurate titration results, obtain a suitable value for the volume of **FA 1** to be use in your calculations.
Show clearly how you obtained this value.

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

(c) Calculations

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

(ii) Calculate the number of moles of potassium manganate(VII) present in the volume calculated in **(b)**.

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

(iii) The equation for the reaction of potassium manganate(VII) with hydrogen peroxide is shown.

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

Use your answer to **(c)(ii)** to calculate the number of moles of hydrogen peroxide used in each titration.

moles of H_2O_2 = ... mol

Hence calculate the concentration of H_2O_2 in **FA 4**, in mol dm^{-3}.

concentration of H_2O_2 in **FA 4** = ... mol dm^{-3} [1]

(iv) Calculate the concentration of H_2O_2 in **FA 3**, in mol dm^{-3}.

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

(v) When hydrogen peroxide decomposes in the presence of a catalyst, oxygen is produced.

$$H_2O_2(aq) \rightarrow H_2O(l) + \tfrac{1}{2}O_2(g)$$

The 'volume strength' of hydrogen peroxide is equal to the volume of oxygen, in dm^3, produced under room conditions, when 1.00 dm^3 of the solution decomposes.

Use your answer to **(c)(iv)** and the equation above to calculate the volume, in dm^3, of oxygen produced when 1.00 dm^3 of **FA 3** decomposes. This is the 'volume strength', in vol, of **FA 3**.

(Under room conditions 1.00 mol of gas occupies a volume of 24.0 dm^3.
If you were unable to calculate the concentration of H_2O_2 in **FA 3**, assume that it is 1.02 mol dm^{-3}. This may **not** be the correct value.)

'volume strength' of **FA 3** = ... vol [2]

(d) The maximum error in reading a 25.0 cm^3 pipette is ±0.06 cm^3.

Show by calculation that the pipette is more accurate than a burette for measuring 25.0 cm^3 of solution.

....

.... [1]

[Total: 15]

2 In this experiment you will determine the enthalpy change, ΔH, for the catalytic decomposition hydrogen peroxide into water and oxygen.

$$H_2O_2(aq) \rightarrow H_2O(l) + \tfrac{1}{2}O_2(g)$$

FA 3 is aqueous hydrogen peroxide, H_2O_2.
FA 5 is manganese(IV) oxide, MnO_2.

(a) Method

Experiment 1

- Support one of the plastic cups inside the 250 cm^3 beaker.
- Use the 50 cm^3 measuring cylinder to add 30 cm^3 of **FA 3** into the plastic cup.
- Measure and record the initial temperature of the solution.
- Add a heaped spatula measure of **FA 5** to the solution in the plastic cup.
- Stir constantly until the maximum temperature is reached and record this temperature.
- Calculate and record the temperature rise.
- Rinse and dry the thermometer.

Experiment 2

- Support the second plastic cup inside the 250 cm^3 beaker.
- Use the 50 cm^3 measuring cylinder to add 40 cm^3 of **FA 3** into the plastic cup.
- Measure and record the initial temperature of the solution.
- Add a heaped spatula measure of **FA 5** to the solution in the plastic cup.
- Stir constantly until the maximum temperature is reached and record this temperature.
- Calculate and record the temperature rise.

I	
II	
III	
IV	
V	

[5]

(b) Calculation

(i) Calculate the energy released in **Experiment 1**.
[Assume that 4.2 J changes the temperature of 1.0 cm^3 of solution by 1.0 °C.]

energy released = ... J [1]

(ii) Use your answer to **1(c)(iv)** to calculate the number of moles of hydrogen peroxide used in **Experiment 1**.
(If you were unable to calculate the concentration of H_2O_2 in **FA 3**, assume that it is 1.02 mol dm^{-3}. This may **not** be the correct value.)

moles of H_2O_2 = ... mol [1]

(iii) Calculate the enthalpy change, in kJ mol^{-1}, for the decomposition of 1 mole of hydrogen peroxide into water and oxygen.

enthalpy change = ... kJ mol^{-1} [1]
sign *value*

(c) (i) A student suggested that the experiment would be more accurate if the same mass of **FA 5**, manganese(IV) oxide, had been weighed out for each experiment.

State and explain whether you agree with the student's suggestion.

....

....

....

.... [2]

(ii) The student also suggested that **Experiments 1** and **2** should give the same temperature rise, even though a greater volume of **FA 3** was used in **Experiment 2**.

State and explain whether you agree with the student's suggestion.

....

....

.... [1]

[Total: 11]

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)** **FA 3** is aqueous hydrogen peroxide, H_2O_2.
FA 6 is a solution containing two cations and one anion from those listed in the Qualitative analysis notes.

(i) To a 1 cm depth of **FA 6** in a boiling tube, add aqueous sodium hydroxide until it is in excess. Then heat the tube, gently and carefully.
Keep the mixture obtained in the boiling tube for the test in **(a)(ii)**.

Record **all** your observations.
Identify the cations in **FA 6**.

observations ....

....

....

....

....

FA 6: cations are .... and ....
[4]

(ii) To the mixture obtained from **(a)(i)**, carefully add a 1 cm depth of **FA 3**.
Record your observations.

....

.... [1]

(iii) One reaction taking place in **(a)(ii)** involves oxidation of one of the cations in **FA 6**.

Give the half-equation to show this oxidation reaction. State symbols are not required.

.... [1]

(b) **FA 1** is aqueous potassium manganate(VII).
FA 2 is dilute sulfuric acid.
FA 7 and **FA 8** are solutions, each containing one cation and one anion.

(i) Carry out the following tests and record your observations in the table.

test	*observations*	
	FA 7	**FA 8**
Test 1 To a 1 cm depth of solution in a test-tube, add a small spatula measure of solid sodium carbonate.		
Test 2 To a 1 cm depth of solution in a test-tube, add an equal volume of **FA 2** and a few drops of **FA 1**, then		
add a few drops of aqueous starch.		
Test 3 To a 1 cm depth of solution in a test-tube, add a few drops of aqueous silver nitrate, then		
add aqueous ammonia.		

[5]

(ii) Identify the anion in **FA 7**.

anion .... [1]

(iii) Identify **FA 8**.

FA 8 is .... [1]

(iv) Carry out one further test to confirm the identity of the cation in **FA 8**.
State the name of the reagent you used and record the observation(s) you made.

reagent ....

observation(s) ....

....
[1]

[Total: 14]

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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	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

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

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			**Key** atomic number atomic symbol name relative atomic mass								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 –		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 –