Cambridge International AS & A Level

Cambridge Assessment International Education
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME	

CENTRE NUMBER							CANDIDATE NUMBER					

1158518121

CHEMISTRY **9701/34**

Paper 3 Advanced Practical Skills 2 **May/June 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.

Cambridge Assessment International Education

[Turn over

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 Iron wire contains impurities. You will investigate the percentage by mass of iron in a sample of iron wire.

A sample of iron wire is reacted with an excess of sulfuric acid to produce a solution of iron(II) sulfate.

$$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$$

You will titrate the solution of iron(II) sulfate with potassium manganate(VII) of known concentration to determine the amount of iron(II) ions present and hence the percentage by mass of iron in the wire. You may assume the impurities do not form any products that react with potassium manganate(VII).

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$$

FB 1 is 0.0200 mol dm^{-3} potassium manganate(VII), $KMnO_4$.
FB 2 is a solution of $FeSO_4$ prepared by reacting 6.02 g of iron wire with sulfuric acid to make 1 dm^3 of solution.
FB 3 is dilute sulfuric acid, H_2SO_4.

(a) Method

- Fill a burette with **FB 1**.
- Pipette 25.0 cm^3 of **FB 2** into a conical flask.
- Use the measuring cylinder to transfer 25 cm^3 of **FB 3** 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 that any recorded results show the precision of your practical work.
- Record all of your burette readings and the volume of **FB 1** added in each accurate titration.

Keep FB 3 for use in Question 2.

Results

I	
II	
III	
IV	
V	
VI	
VII	

[7]

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

25.0 cm^3 of **FB 2** required .... cm^3 of **FB 1**. [1]

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

(ii) Use your answer to **(b)** to calculate the number of moles of potassium manganate(VII), **FB 1**, which reacted with 25.0 cm^3 of **FB 2**.

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

(iii) Use the information on page 2 to calculate the number of moles of iron(II) ions present in 25.0 cm^3 of **FB 2**.

moles of Fe^{2+} = ... mol [1]

(iv) Calculate the mass of iron present in 25.0 cm^3 of **FB 2**.

mass of Fe = ... g [1]

(v) Calculate the percentage by mass of iron in the sample of iron wire.

percentage by mass of iron in iron wire = ... % [1]

(d) A student suggested that when a piece of iron wire was dissolved in a known volume and concentration of sulfuric acid, the number of moles of iron that reacted with the acid could be determined by working out how much acid was left after the reaction. The amount of excess acid could be determined by titrating the mixture with a known concentration of sodium hydroxide.

Explain whether the student was correct.

....

....

.... [1]

[Total: 14]

2 In **Question 1** you used dilute sulfuric acid, **FB 3**. You will now determine the concentration of **FB 3** by measuring the temperature of its reaction with sodium hydroxide.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

FB 4 is 0.90 mol dm^{-3} sodium hydroxide, NaOH.

(a) Method

- Fill the second burette with **FB 4**.
- Support the plastic cup in the 250 cm^3 beaker.
- Pipette 10.0 cm^3 of **FB 3** into the plastic cup.
- Place the thermometer into the **FB 3**. Tilt the cup so that the bulb of the thermometer is surrounded by solution. Record the temperature in the table below. This is the temperature of the solution before any **FB 4** has been added.
- Add 5.00 cm^3 of **FB 4** from the burette to the **FB 3** in the plastic cup. Stir the mixture and record the temperature reached. Record the volume of **FB 4** added.
- Add a second 5.00 cm^3 portion of **FB 4** to the plastic cup, stir the mixture and record the temperature reached. Record the total volume of **FB 4** added.
- Continue adding 5.00 cm^3 portions of **FB 4** until 40.00 cm^3 have been added. After each addition, stir and record the temperature reached and total volume of **FB 4** added.

Results

total volume of **FB 4** added / cm^3	temperature of solution / °C

[3]

(b) Plot a graph of temperature of solution on the *y*-axis against total volume of **FB 4** added on the *x*-axis. Select a scale on the *y*-axis to include a temperature of 2.0 °C above your maximum thermometer reading. Label any points you consider to be anomalous. You will use the graph to find the volume of **FB 4** needed to neutralise 10.0 cm^3 of **FB 3**.

I	
II	
III	
IV	

Draw two lines of best fit through the points on your graph, the first for the increase in temperature and the second for the decrease in temperature of the mixtures. Extrapolate the two lines so they intersect and hence determine the volume of **FB 4** required to neutralise 10.0 cm^3 of **FB 3**.

volume of **FB 4** = ... cm^3
[4]

(c) **(i)** Use your answer to **(b)** to calculate the number of moles of sodium hydroxide required to neutralise 10.0 cm^3 of **FB 3**.

moles of NaOH = ... mol [1]

(ii) Calculate the number of moles of sulfuric acid present in 10.0 cm^3 of **FB 3**.

moles of H_2SO_4 = ... mol

Hence calculate the concentration, in mol dm^{-3}, of sulfuric acid in **FB 3**.

concentration of H_2SO_4 in **FB 3** = ... mol dm^{-3} [1]

(d) Explain how you would use the data obtained in **Question 2** to calculate the enthalpy change of neutralisation of the sulfuric acid. You do not need to carry out the calculation.

....

....

....

.... [3]

[Total: 12]

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) **FB 5** is a solution of a sodium salt of an organic acid.

FB 6 and **FB 7** each contain one cation and one anion from those listed in the Qualitative Analysis Notes.

Carry out the following tests and record your observations.
Use a separate 1 cm depth of each solution in a test-tube for each test.

test	*observations*		
	FB 5	**FB 6**	**FB 7**
Add 2 or 3 drops of acidified potassium manganate(VII).			
If there is no visible change, pour into a boiling tube and warm gently.			
Add a 1 cm depth of dilute nitric acid, then			
add 2 or 3 drops of aqueous silver nitrate.			
Add a 1 cm depth of dilute hydrochloric acid, then			
add a 1 cm depth of aqueous barium nitrate or aqueous barium chloride.			
Add a 1 cm depth of **FB 5** and leave to stand for a few minutes.			

[7]

(b) (i) Select reagents for two further tests to help identify the cations present in **FB 6** and **FB 7**.

Record in a suitable form below the reagents you use and your observations.

[4]

(ii) Use your observations to identify as many ions as possible. Give the formula of the ion present. Write ‘unknown’ if you were unable to identify an ion.

	FB 6	**FB 7**
cation		
anion		

[2]

(iii) Write an ionic equation for any precipitation reaction observed involving **FB 7**. Include state symbols.

.... [1]

[Total: 14]

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 –