Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME						
CENTRE NUMBER					CANDIDATE NUMBER	

0695569070

CHEMISTRY **9701/33**

Paper 3 Advanced Practical Skills 1 **October/November 2018**

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 14 and 15.
A copy of the Periodic Table is printed on page 16.

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 **14** printed pages and **2** blank pages.

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CAMBRIDGE International Examinations

[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 You will determine the enthalpy change, ΔH, for the reaction between magnesium and aqueous copper(II) sulfate. To do this you will measure the change in temperature when magnesium powder reacts with aqueous copper(II) sulfate. The magnesium is in excess.

$$Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$$

FA 1 is a solution containing 151.9 g dm^{-3} copper(II) sulfate, $CuSO_4$.
FA 2 is magnesium powder, Mg.

(a) Method

- Weigh the container with **FA 2** and record the mass in the space below.
- Support the plastic cup in the 250 cm^3 beaker.
- Use the measuring cylinder to transfer 25 cm^3 of **FA 1** into the plastic cup.
- Place the thermometer in the solution and tilt the cup if necessary so that the bulb of the thermometer is fully covered. Record the temperature at time zero in the table of results.
- Start timing and do not stop the clock until the whole experiment has been completed.
- Record the temperature of the solution every half minute for 2 minutes.
- At $2\frac{1}{2}$ minutes carefully transfer **all** of **FA 2** into the solution in the cup and stir the mixture.
- Record the temperature of the mixture at 3 minutes and complete the table by recording the temperature every half minute. Stir the mixture continuously between thermometer readings.
- Weigh the container with any residual **FA 2** and record the mass below.
- Calculate and record the mass of **FA 2** used.

Keep FA 1 for use in Question 2.

Results

time / minutes	0	$\frac{1}{2}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4
temperature / °C									

time / minutes	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8
temperature / °C								

[4]

(b) (i) Plot a graph of temperature on the *y*-axis against time on the *x*-axis on the grid below.
The scale for temperature should extend at least 10 °C above your highest recorded temperature.
You will use the graph to determine the theoretical maximum temperature rise at $2\frac{1}{2}$ minutes.
Draw two lines of best fit through the points on your graph, the first for the temperature before adding **FA 2** and the second for the cooling of the mixture. Label any points you consider anomalous.

I	
II	
III	

[3]

(ii) Extrapolate the two lines to $2\frac{1}{2}$ minutes, draw a vertical line between the two lines of best fit and so determine the theoretical rise in temperature, ΔT, at this time.

ΔT = ... °C
[2]

(c) Calculations

(i) Use the information given to calculate the concentration of copper(II) sulfate in **FA 1** in $mol\,dm^{-3}$.

concentration of **FA 1** = ... $mol\,dm^{-3}$ [1]

(ii) Hence calculate the number of moles of copper(II) sulfate you used in **(a)**.

moles of $CuSO_4$ = ... mol [1]

(iii) Use your answer to **(b)(ii)** to calculate the heat energy evolved when **FA 2** is added to **FA 1**. (Assume 4.2 J of heat energy changes the temperature of $1.0\,cm^3$ of the mixture by 1.0 °C.)

heat energy evolved = ... J [1]

(iv) Calculate the enthalpy change, in $kJ\,mol^{-1}$, when 1 mole of $CuSO_4$ reacts with magnesium.

enthalpy change = ... $kJ\,mol^{-1}$ [1]
(sign) (value)

(v) Show by calculation that the magnesium was in excess.

[1]

(d) (i) A student suggested that the calculated enthalpy change would be more accurate if magnesium turnings were used instead of magnesium powder.

State whether you agree with the student and give a reason for your answer.

....

....

.... [1]

(ii) The enthalpy change determined in **(c)(iv)** is only an approximation of the actual value.

Suggest and explain **one** improvement to the **method** in **(a)** you would make to increase the accuracy of the experiment.

....

....

.... [1]

[Total: 16]

[Turn over

2 In this experiment you will determine the enthalpy change, ΔH, for the reaction between aqueous copper(II) sulfate and zinc. The zinc is in excess. The method used in this question is slightly different from that used in **Question 1**.

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

FA 3 is zinc powder, Zn.

(a) Method

- Weigh a clean, dry plastic cup and record the mass.
- Add between 1.8 g and 2.0 g of zinc powder, **FA 3**, and record the mass.
- Place the plastic cup in the 250 cm^3 beaker.
- Pour 25 cm^3 of **FA 1** into the 25 cm^3 measuring cylinder.
- Place the thermometer in the solution in the measuring cylinder and record the initial temperature.
- Pour the 25 cm^3 of **FA 1** into the plastic cup.
- Stir the contents of the cup and record the highest temperature of the mixture. Tilt the cup if necessary to ensure the thermometer bulb is fully covered.
- Calculate and record the mass of **FA 3** used and the change in temperature.

Keep the remainder of FA 3 for use in Question 3.

Results

[3]

(b) Calculations

(i) Use your answer to **1(c)(ii)** and the volume of **FA 1** used in **2(a)** to calculate the enthalpy change, in $kJ\,mol^{-1}$, when 1 mole of $CuSO_4$ reacts with zinc.
(Assume 4.2 J of heat energy changes the temperature of $1.0\,cm^3$ of the mixture by 1.0 °C.)

enthalpy change = ... $kJ\,mol^{-1}$ [2]
(sign) (value)

(ii) The maximum error in a single thermometer reading is ±0.5 °C.

Calculate the maximum percentage error in the temperature change for the experiment in **(a)**.

maximum percentage error = ... % [1]

(c) A student decided to repeat this experiment using the same concentration of copper(II) sulfate solution and the same batch of zinc powder. However, $50\,cm^3$ of **FA 1** and double the mass of **FA 3** were used.

What effect would doubling the quantities of **FA 1** and **FA 3** have on the temperature rise?
The possible results are listed below.

The temperature rise would be approximately half that for the first experiment.	☐
The temperature rise would be approximately the same as that for the first experiment.	☐
The temperature rise would be approximately double that for the first experiment.	☐

Tick the box you think correct and explain your answer.

....

....

....
[1]

(d) Use the information given in **Question 1** and **Question 2** and your answers to **1(c)(iv)** and **2(b)(i)** to construct a Hess' cycle diagram for the reaction between magnesium and zinc sulfate to form magnesium sulfate and zinc.

Calculate the enthalpy change for this reaction.

(If you were unable to complete the calculations then assume the enthalpy change for **1(c)(iv)** is –320 kJ mol^{-1} and the enthalpy change for **2(b)(i)** is –201 kJ mol^{-1}. These are not the correct values.)

enthalpy change = ... kJ mol^{-1} [2]
(sign) (value)

[Total: 9]

Qualitative Analysis

Where reagents are selected for use in a test, the **full 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 4** is a solution of a transition metal compound dissolved in acid.

Carry out the following tests on **FA 4** and record your observations.

test	*observations*
To a 1 cm depth of **FA 4** in a test-tube, add a 1 cm depth of potassium iodide, then	
add aqueous sodium thiosulfate.	
To a 3 cm depth of **FA 4** in a boiling tube, add a spatula measure of zinc powder, **FA 3**. If no reaction occurs, **carefully** warm the mixture. Leave the mixture for 5–15 minutes, observing the mixture occasionally.	
Keep the mixture of FA 4 and FA 3 for use in (c). The solution formed from the mixture is **FA 6**. Complete part **(b)** while **FA 4** and **FA 3** continue reacting.	

[5]

(b) **(i)** **FA 5** is the acid used to make **FA 4**. The anion in **FA 5** is listed in the Qualitative Analysis Notes.

List the reagents you would use to identify this anion and state which acid the reagents are testing for.

[2]

(ii) Carry out **one** of your tests in **(i)** and record your observations.

Give the formula of the anion present in **FA 5**. Write 'unknown' if your test could not positively identify this anion.

....

[2]

(c) Carry out the following tests on **FA 6** (the solution formed in **(a)**).

test	*observations*
To a 1 cm depth of **FA 6** in a test-tube, add acidified potassium manganate(VII) a few drops at a time until in excess. At this stage the solution will be pink.	
To a 1 cm depth of **FA 6** in a test-tube, add a 1 cm depth of **FA 4**.	

[3]

(d) **(i)** State the type of reaction occurring in **(c)** when acidified potassium manganate(VII) was added to **FA 6**.
Give a reason for your answer.

....

.... [2]

(ii) The ion present in **FA 4** when in acidic solution is usually written as $\mathbf{M}O_2^{+}$ where **M** represents the transition metal.

Calculate the oxidation state of **M** in $\mathbf{M}O_2^{+}$.

oxidation state of **M** = ... [1]

[Total: 15]

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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	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											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	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 –