Cambridge International AS & A Level

Cambridge International Examinations
Cambridge International Advanced Subsidiary and Advanced Level

CANDIDATE NAME			
CENTRE NUMBER		CANDIDATE NUMBER	

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CHEMISTRY **9701/36**

Paper 3 Advanced Practical Skills 2 **October/November 2016**

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.

IB16 11_9701_36/3RP

CAMBRIDGE International Examinations

1 Zinc metal is extracted from ores that, in addition to compounds of zinc, can also contain copper and silver. This means zinc metal is often impure.

You will investigate the percentage purity of a sample of zinc by reacting it with excess aqueous copper(II) sulfate and comparing the enthalpy change of the displacement reaction with the accepted value.

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

FB 1 is 1.00 mol dm^{-3} copper(II) sulfate, $CuSO_4$.
FB 2 is powdered impure zinc, Zn.

(a) Method

Read the whole method before starting any practical work.

- Weigh the container with **FB 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 **FB 1** into the plastic cup.
- Place the thermometer in the solution and record the initial temperature in a suitable table of results. Tilt the cup if necessary so that the bulb of the thermometer is fully covered. This is the temperature at time zero (t = 0).
- Start timing and do not stop the clock until the whole experiment has been completed at t = 8 minutes.
- Measure and record the temperature of the **FB 1** in the cup every half minute up to and including t = 2 minutes.
- At $t = 2\frac{1}{2}$ minutes add all the **FB 2** into the cup and stir the contents until t is nearly 3 minutes.
- Measure and record the temperature of the mixture in the cup every half minute from t = 3 minutes until t = 8 minutes. Stir occasionally throughout this time.
- Weigh the container and any residual **FB 2**. Record this mass and calculate the mass of **FB 2** added.

Results

Mass

Temperature

I	
II	
III	
IV	

[4]

(b) 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 3 °C above your highest recorded temperature.
You will use the graph to determine the theoretical maximum temperature rise at $t = 2\frac{1}{2}$ minutes.

I	
II	
III	
IV	

Draw two lines of best fit through the points on your graph, the first for the temperature before adding **FB 2** and the second for the temperature of the mixture after addition of **FB 2**.
Extrapolate the lines to $t = 2\frac{1}{2}$ minutes and determine the theoretical maximum temperature rise, ΔT.

theoretical maximum temperature rise at $t = 2\frac{1}{2}$ minutes, ΔT = ... °C [4]

(c) Calculations

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

(i) Use your answer to **(b)** to calculate the heat energy, in J, given out when **FB 2** was added to the **FB 1** in the cup.
(Assume that 4.2 J of heat energy raises the temperature of 1.0 cm^3 of the mixture by 1.0 °C.)

heat energy given out = ... J

(ii) Use your answer to **(i)** and the Periodic Table on page 12 to calculate the enthalpy change, in kJ mol^{-1}, for the displacement reaction.

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

You should assume that **FB 2** was pure zinc for this calculation.

enthalpy change, ΔH = ... kJ mol^{-1}
(sign) (value)

[3]

(d) The accepted value for the enthalpy change of this reaction is –217 kJ mol^{-1}.

Assuming no heat loss and that the other metals present in **FB 2** do not react with aqueous copper(II) sulfate, calculate the percentage of zinc present in **FB 2**.

percentage of Zn = ... % [1]

(e) A student carried out the same experiment but used pieces of zinc instead of zinc powder. All quantities and the initial temperature of the aqueous copper(II) sulfate remained the same.

State and explain what effects this change would have on the graph plotted.

....

....

....

.... [2]

[Total: 14]

2 Solid hydrated copper(II) sulfate has the formula $CuSO_4.\mathbf{x}H_2O$ where **x** is the number of moles of water of crystallisation present in 1 mole of compound.

You will determine the equation for the reaction that occurs when hydrated copper(II) sulfate is heated to remove the water of crystallisation producing anhydrous copper(II) sulfate.

FB 3 is hydrated copper(II) sulfate $CuSO_4.\mathbf{x}H_2O$.

(a) Method
Record all masses in the space below.

- Weigh the crucible and add 2.2–2.4 g of **FB 3**.
- Weigh the crucible plus **FB 3**.
- Place the crucible on the pipe-clay triangle and heat it gently for approximately 4 minutes.
- Leave the crucible to cool and reweigh the crucible plus residue.

Keep the crucible and residue for test (c).

I	
II	
III	
IV	

[4]

(b) Calculations

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

(i) Calculate the mass of anhydrous copper(II) sulfate, $CuSO_4$, produced after heating.

mass of $CuSO_4$ = ... g

(ii) Calculate the mass of water lost by heating.

mass of water = ... g

(iii) Use your answers to **(i)** and **(ii)** and the Periodic Table on page 12 to deduce the value of **x** in the formula $CuSO_4.\mathbf{x}H_2O$.

x is ....

(iv) Use your answer to **(iii)** to complete the equation for the reaction that occurs when hydrated copper(II) sulfate is heated. You should include state symbols.

$CuSO_4$.......H_2O(.......) → $CuSO_4$(.......) + ...H_2O(.......)

[4]

(c) Place the cooled crucible, with the residue, **on a heatproof mat** and carefully add a few drops of water.

(i) Note your observations.

....

....

(ii) Explain your observations in **(i)** in terms of the reaction occurring.

....

....

....

[3]

(d) Two students carried out the experiment in **(a)** and obtained values for **x** that did not agree with the accepted value. One student calculated a value that was less than the accepted value and the other student calculated a value that was more than the accepted value.

In each case, suggest a reason for the error and an improvement that could be made to minimise it. You can assume that the calculations were correctly carried out.

Value less than accepted value

error ....

improvement ....

Value more than accepted value

error ....

improvement ....

[2]

[Total: 13]

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) **FB 4** and **FB 5** are aqueous solutions of equal concentrations, in mol dm^{-3}. Each contains one anion and one cation. The cation is the same in both **FB 4** and **FB 5**.

Half fill the 250 cm^3 beaker with water. Heat the water to about 80 °C and then turn off the Bunsen burner. This is the hot water bath needed in the tests below.

To about a 2 cm depth of aqueous silver nitrate in a test-tube, add a few drops of aqueous sodium hydroxide to give a grey / brown precipitate. Then add aqueous ammonia dropwise until the precipitate **just** disappears. This solution is Tollens' reagent and is needed in a test below.

(i) Carry out the tests on separate samples of **FB 4** and **FB 5** and complete the table.

test	*observations*	
	FB 4	**FB 5**
To a 1 cm depth of solution in a test-tube in a test-tube rack, add a spatula measure of sodium carbonate.		
To a 1 cm depth of solution in a test-tube, add a few drops of acidified potassium manganate(VII). Place the test-tube in the hot water bath.		
To a 1 cm depth of Tollens' reagent in a test-tube, add a few drops of solution. Place the test-tube in the hot water bath and leave for several minutes.		

(ii) From your observations in **(i)**, identify the cation present in **both FB 4** and **FB 5**.

cation ....

(iii) From your observations in **(i)**, what can be deduced about the anion present in **FB 4**?

....

(iv) Place a 1 cm depth of **FB 4** and **FB 5** separately in two test-tubes.

Measure and record the temperature of the two solutions.

FB 4 .... °C **FB 5** .... °C

To each solution, add an approximately 2 cm length of magnesium ribbon. Measure and record the maximum temperature reached in each test-tube.

FB 4 + Mg .... °C **FB 5** + Mg .... °C

(v) Explain why there is a difference in the temperature rise for the reactions of magnesium with solutions **FB 4** and **FB 5**.

....

....

....

[8]

(b) **FB 6** is a solid that contains two cations from those listed on page 10.

You are to plan a series of experiments that will enable you to identify the cations present. You should then carry out your plan, record all the observations you made in a suitable table and identify the cations present.

cations present are .... and .... [5]

[Total: 13]

Qualitative Analysis Notes

Key: [ppt. = precipitate]

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)	no ppt. (if 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; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO_2 in air)
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 –