Cambridge International AS & A Level

Cambridge International Advanced Subsidiary and Advanced Level

	CANDIDATE NAME												
	CENTRE NUMBER				CANDIE NUMBE								
* 1 7 5 (	CHEMISTRY	9701/36											
5 0	Paper 3 Advance	ed Practical S	kills 2			October/November 2016							
	2 hour Candidates answer on the Question Paper.												
					nfidential Instructions								
	Additional Materia												
	READ THESE INSTRUCTIONS FIRST												
	Write your Centre Give details of the Write in dark blue You may use an I Do not use staple DO <b>NOT</b> WRITE Answer <b>all</b> questi Electronic calcula You may lose ma Use of a Data Bo	e practical ses e or black pen HB pencil for es, paper clips IN ANY BAR( tions. ators may be u arks if you do r	oxes pro										
			Jeecear J.				Se	ssion	1				
	Qualitative Analys A copy of the Per												
	At the end of the The number of m part question.		Laboratory										
	F d					L							
						Fo	r Exar	niner	's Use	;			
							1						
							2						
							3						

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

Total

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  $1.00 \text{ mol dm}^{-3} \text{ copper}(\text{II})$  sulfate,  $\text{CuSO}_4$ . **FB 2** is powdered impure zinc, Zn.

## (a) Method

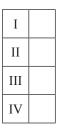
#### Read the whole method before starting any practical work.

- Weigh the container with **FB 2** and record the mass in the space below.
- Support the plastic cup in the 250 cm<sup>3</sup> beaker.
- Use the measuring cylinder to transfer 25 cm<sup>3</sup> 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

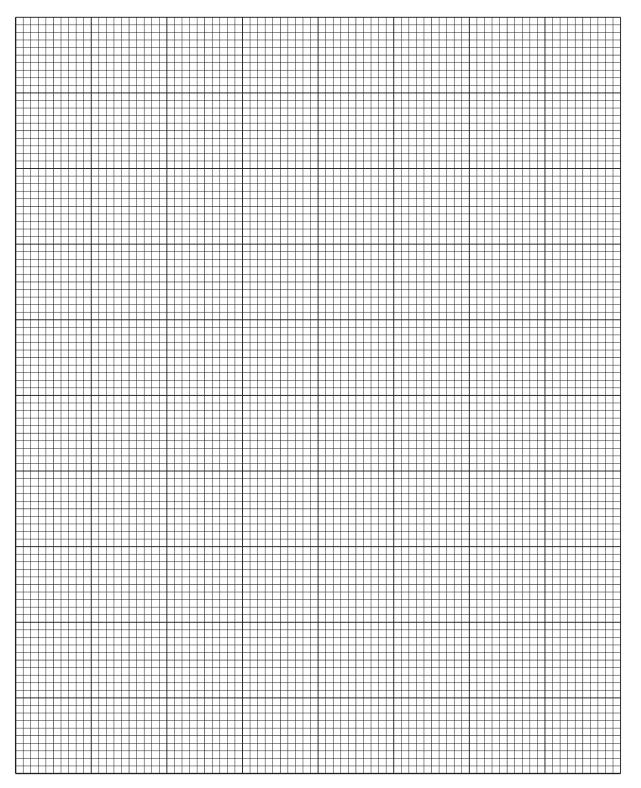
Mass

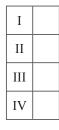
#### Temperature



[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.





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,  $\Delta T$ .

theoretical maximum temperature rise at  $t = 2\frac{1}{2}$  minutes,  $\Delta T = \dots \circ C$  [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 4.2J of heat energy raises the temperature of 1.0 cm<sup>3</sup> 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<sup>-1</sup>, 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,  $\Delta H = \dots$  kJ mol<sup>-1</sup> (sign) (value) [3]

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

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 Solid hydrated copper(II) sulfate has the formula CuSO<sub>4</sub>.**x**H<sub>2</sub>O 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.

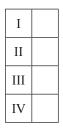
**FB 3** is hydrated copper(II) sulfate  $CuSO_4$ .**x**H<sub>2</sub>O.

# (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).



[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<sub>4</sub>, 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<sub>4</sub>.xH<sub>2</sub>O.

**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.

$$CuSO_4....H_2O(...) \rightarrow CuSO_4(...) + ...H_2O(...)$$

[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]

## 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<sup>-3</sup>. Each contains one anion and one cation. The cation is the same in both **FB 4** and **FB 5**.

Half fill the 250 cm<sup>3</sup> 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 2cm 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.

40.04	observ	vations
test	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 Explain why there is a difference in the temperature rise for the reactions of magnesium (v) 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

ian	reaction with									
ion	NaOH(aq)	NH <sub>3</sub> (aq)								
aluminium, A <i>l</i> ³⁺(aq)	white ppt. soluble in excess	white ppt. insoluble in excess								
ammonium, NH₄⁺(aq)	no ppt. ammonia produced on heating	_								
barium, Ba²⁺(aq)	no ppt. (if reagents are pure)	no ppt.								
calcium, Ca²⁺(aq)	white ppt. with high [Ca <sup>2+</sup> (aq)]	no ppt.								
chromium(III), Cr³⁺(aq)	grey-green ppt. soluble in excess	grey-green ppt. insoluble in excess								
copper(II), Cu²+(aq)	pale blue ppt. insoluble in excess	blue ppt. soluble in excess giving dark blue solution								
iron(II), Fe²⁺(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), Fe³⁺(aq)	red-brown ppt. insoluble in excess	red-brown ppt. insoluble in excess								
magnesium, Mg²+(aq)	white ppt. insoluble in excess	white ppt. insoluble in excess								
manganese(II), Mn²⁺(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, Zn²⁺(aq)	white ppt. soluble in excess	white ppt. soluble in excess								

# 2 Reactions of anions

ion	reaction
carbonate, CO <sub>3</sub> <sup>2–</sup>	CO <sub>2</sub> liberated by dilute acids
chloride, C <i>l⁻</i> (aq)	gives white ppt. with Ag⁺(aq) (soluble in NH₃(aq))
bromide, Br⁻(aq)	gives cream ppt. with Ag <sup>+</sup> (aq) (partially soluble in $NH_3(aq)$ )
iodide, I⁻(aq)	gives yellow ppt. with Ag <sup>+</sup> (aq) (insoluble in NH <sub>3</sub> (aq))
nitrate, NO₃⁻(aq)	$NH_3$ liberated on heating with $OH^-(aq)$ and $Al$ foil
nitrite, NO₂⁻(aq)	NH <sub>3</sub> liberated on heating with OH <sup>-</sup> (aq) and A <i>l</i> foil; NO liberated by dilute acids (colourless NO $\rightarrow$ (pale) brown NO <sub>2</sub> in air)
sulfate, SO₄²⁻(aq)	gives white ppt. with Ba <sup>2+</sup> (aq) (insoluble in excess dilute strong acids)
sulfite, SO <sub>3</sub> ²-(aq)	gives white ppt. with Ba <sup>2+</sup> (aq) (soluble in excess dilute strong acids)

# 3 Tests for gases

gas	test and test result
ammonia, NH <sub>3</sub>	turns damp red litmus paper blue
carbon dioxide, CO <sub>2</sub>	gives a white ppt. with limewater (ppt. dissolves with excess CO <sub>2</sub> )
chlorine, $Cl_2$	bleaches damp litmus paper
hydrogen, H <sub>2</sub>	"pops" with a lighted splint
oxygen, O <sub>2</sub>	relights a glowing splint

								Gr	oup								
1	2						·					13	14	15	16	17	1
				Key			1 H hydrogen 1.0										H hel 4
3 Li lithium 6.9	4 Be beryllium 9.0		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	1 N ne 20
11 Na sodium 23.0	12 Mg magnesium 24,3	3	4	5	6	7	8	9	10	11	12	13 A1 aluminium 27.0	14 Si silicon 28.1	15 P phosphorus 31.0	16 S sulfur 32.1	17 C1 chlorine 35.5	1 
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	kry 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 <sup>ruthenium</sup> 101.1	45 Rh <sup>rhodium</sup> 102.9	46 Pd palladium 106.4	47 Ag silver 107.9	48 Cd cadmium 112.4	49 In indium 114.8	50 Sn <sup>tin</sup> 118.7	51 Sb antimony 121.8	52 Te tellurium 127.6	53 I iodine 126.9	× × 13
55 Cs caesium 132.9	56 Ba barium 137.3	57–71 Ianthanoids	72 Hf <sup>hafnium</sup> 178.5	73 Ta tantalum 180.9	74 W tungsten 183.8	75 Re <sup>rhenium</sup> 186.2	76 Os osmium 190.2	77 Ir iridium 192.2	78 Pt platinum 195.1	79 Au <sub>gold</sub> 197.0	80 Hg mercury 200.6	81 T <i>l</i> thallium 204.4	82 Pb lead 207.2	83 Bi bismuth 209.0	84 Po polonium	85 At astatine	F ra
87 Fr francium	88 Ra radium	89–103 actinoids	104 Rf rutherfordium	105 Db dubnium	106 Sg seaborgium	107 Bh bohrium	108 Hs <sub>hassium</sub>	109 Mt <sup>meitnerium</sup>	110 Ds darmstadtium	111 Rg roentgenium	112 Cn copernicium		114 Fl flerovium		116 Lv livermorium		
	1						1									1	1
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 <sup>europium</sup> 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 <sup>Iutetium</sup> 175.0	
actinoids		89 Ac actinium	90 Th thorium 232.0	91 Pa protactinium	92 U uranium	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	

12