HWA CHONG INSTITUTION
C2 Preliminary Examination
Higher 2

NAME		**CT GROUP**	**17S**

CHEMISTRY **9729/04**

Paper 4 Practical

24 August 2018

2 hours 30 minutes

Candidates answer on the Question Paper

READ THESE INSTRUCTIONS FIRST

Write your name and class on all the work you hand in.
Give details of the practical shift 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.

Answer **all** questions in the spaces provided on the Question Paper.

The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.
Qualitative Analysis Notes are printed on pages 17 and 18.

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.

Shift
Laboratory

For Examiner's Use	
1	
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Deductions	
Total	

Answer **all** the questions in the spaces provided.

1 To determine the concentration of potassium iodate(V)

FA 1 is a solution containing potassium iodate(V), KIO_3.
FA 2 is 1.0 mol dm^{-3} sulfuric acid, H_2SO_4.
FA 3 is 0.50 mol dm^{-3} potassium iodide, KI.
FA 4 is approximately 0.1 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.

You are also provided with starch solution.

You are to determine the concentration of potassium iodate(V) present in **FA 1**.

In acidic conditions, potassium iodate(V) oxidises iodide ions to iodine. Titration of this iodine with a standard solution of sodium thiosulfate allows the concentration of potassium iodate(V) to be determined.

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O \qquad \textbf{reaction 1}$$

$$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-} \qquad \textbf{reaction 2}$$

The solution of **FA 1** is too concentrated to titrate directly with the **FA 4** solution. You will prepare a diluted solution of **FA 1**.

You will then use **FA 4** to determine the concentration of potassium iodate(V) in the diluted solution by titration, and hence determine the concentration of potassium iodate(V) in **FA 1**.

(a) Dilution of FA 1

You will now follow the instructions given below to prepare a diluted solution of **FA 1.**

1. Using a burette, measure between 49.00 cm^3 and 49.50 cm^3 of **FA 1** into the 250 cm^3 graduated flask.

   In the space below, record your burette readings and the volume of **FA 1** added to the flask. Make certain that your recorded results show the precision of your working.

2. Make up the contents of the flask to the 250 cm^3 mark with deionised water. Place the stopper in the flask and mix the contents thoroughly. This solution is **FA 5.**

(b) Titration of FA 5 with FA 4

(i) Titration

1. Fill a burette with **FA 4**.
2. Pipette 25.0 cm^3 of **FA 5** into a conical flask.
3. Use appropriate measuring cylinders to add to this flask
   - 20 cm^3 of **FA 2**,
   - 10 cm^3 of **FA 3**.
4. Run **FA 4** from the burette into the flask until the solution becomes pale yellow.
5. Add about 10 drops of starch solution to this flask and continue adding **FA 4** until the blue-black colour **just** disappears.
6. Record your titration results in the space below. Make certain that your recorded results show the precision of your working.
7. Repeat the titration as many times as you think necessary to obtain accurate results.

Titration results

(ii) Mean titre

From your titrations, obtain a suitable volume of **FA 4** to be used in your calculations. Show clearly how you obtained this volume.

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Volume of **FA 4** = …………………

[7]

Standardisation of FA 4 (You are not required to carry out this experiment.)

The solution of sodium thiosulfate, **FA 4**, you are provided with is approximately 0.1 mol dm^{-3}. The exact concentration has been determined by titrating it with a standard solution of 0.750 volume hydrogen peroxide.

In acidic conditions, hydrogen peroxide oxidises iodide ions to iodine.

$$H_2O_2 + 2I^- + 2H^+ \rightarrow I_2 + 2H_2O \qquad \textbf{reaction 3}$$

The liberated iodine is then titrated against **FA 4**. The procedure used is given below.

- A burette was filled with **FA 4**.
- 25.0 cm^3 of hydrogen peroxide was pipetted into a conical flask.
- 50 cm^3 of **FA 2** and 20 cm^3 of **FA 3** were added to the conical flask.
- About 6 drops of ammonium molybdate was added as a catalyst as **reaction 3** is slow.
- **FA 4** was added from the burette to the flask until the solution became pale yellow.
- 10 drops of starch solution were added to the flask.
- More **FA 4** was added from the burette to the flask until the blue-black colour **just** disappeared.

The volume of **FA 4** added was 31.50 cm^3.

Calculations

(c) **(i)** Hydrogen peroxide decomposes to form water and oxygen gas only.

The concentration of hydrogen peroxide solution is often expressed as a *volume strength*.

This term refers to the volume of oxygen evolved at room temperature and pressure when the hydrogen peroxide in 1.00 cm^3 of solution is fully decomposed.

For example, *10 volume* hydrogen peroxide produces 10 cm^3 of oxygen gas at room temperature and pressure from 1.00 cm^3 of the solution.

Calculate the concentration, in mol dm^{-3}, of hydrogen peroxide used for the standardisation of **FA 4**.
(The molar volume of a gas at room temperature and pressure = 24.0 dm^3 mol^{-1}.)

Concentration of hydrogen peroxide = ……………………… mol dm^{-3} [2]

(ii) Calculate the concentration, in mol dm^{-3}, of sodium thiosulfate in **FA 4**.

[$Na_2S_2O_3$] in **FA 4** = ……………………… mol dm^{-3} [1]

(iii) Calculate the concentration, in mol dm^{-3}, of potassium iodate(V) in **FA 5**.

[KIO_3] in **FA 5** = ……………………… mol dm^{-3} [2]

(iv) Calculate the concentration, in mol dm^{-3}, of potassium iodate(V) in **FA 1**.

[KIO_3] in **FA 1** = ……………………… mol dm^{-3} [1]

(d) The standardisation of **FA 4** was repeated using hydrogen peroxide solution that was contaminated with transition metal ions, which act as catalysts for the decomposition of hydrogen peroxide. Deduce and explain what effect this would have had on the calculated value of the concentration of potassium iodate(V) in **FA 1**.

Effect ……………………………………………………………………………………………

Explanation ……………………………………………………………………………………

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[Total: 15]

2 Investigation of the dissolution of potassium iodide and lithium chloride in water

FA 6 is a mixture containing equal masses of potassium iodide, KI, and lithium chloride, Li*Cl*.

The change in temperature of water per gram of Li*Cl* dissolved may be found by first determining the relationship between mass of KI dissolved in water and the change in temperature of the water due to the dissolution. The temperature change when **FA 6** dissolves completely in water is then determined.

(a) Dissolution of potassium iodide

Different masses of KI were added separately to 25.0 cm^3 of water across four experiments. The initial and minimum temperatures of the water and resultant solution were recorded in Table 2.1 along with other relevant data.

Table 2.1

mass of KI /g	initial temperature of water /^oC	minimum temperature of solution /^oC	decrease in temperature, ΔT /^oC
2.00	29.8	27.4	2.4
4.00	29.8	25.7	4.1
6.00	29.8	23.6	6.2
8.00	29.8	22.0	7.8

Using the results above, plot a graph of ΔT, on the *y*-axis, against mass of KI, on the *x*-axis, on the grid in Fig. 2.1. Draw the most appropriate line, taking into account all of your points.

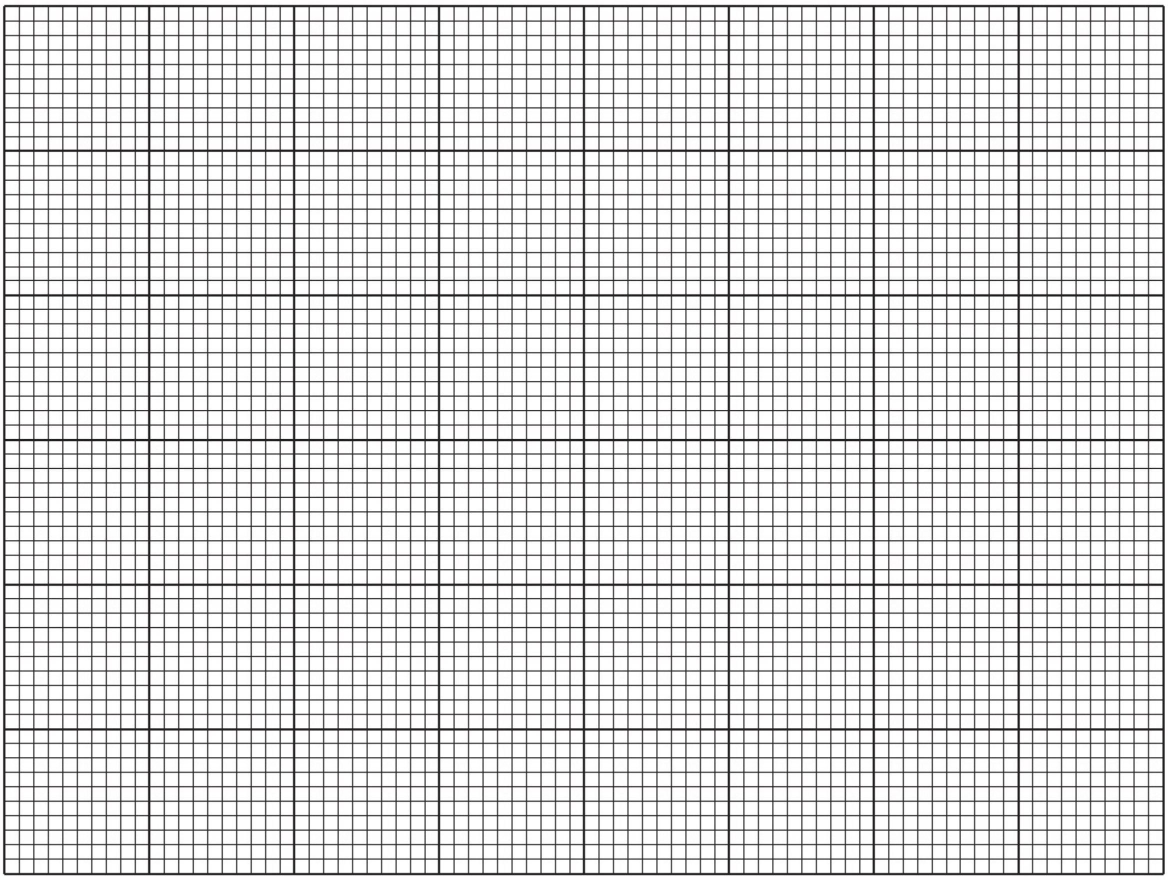

Fig. 2.1 [4]

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(b) **Dissolution of FA 6 in water**

Follow the instructions below to determine the temperature change when **FA 6** dissolves completely in water.

In an appropriate format in the space provided below, record all relevant values for the experiment in part **(b)**.

1. Weigh accurately about 6.0 g of **FA 6** using a weighing bottle.
2. Using a measuring cylinder, transfer 25 cm^3 of deionised water into a Styrofoam cup. Place the cup inside a second Styrofoam cup which is held in a glass beaker to prevent it from tipping over. Place a lid on the cup and insert the thermometer through the lid.
3. Stir the deionised water in the Styrofoam cup with the thermometer. Read and record its temperature. This is the initial temperature of the deionised water.
4. Open the lid and empty the weighing bottle of **FA 6** into the Styrofoam cup of deionised water. Close the lid and stir the solution with the thermometer. Read and record the temperature that shows the greatest change from the initial temperature of the solution.
5. Reweigh the weighing bottle to determine the mass of **FA 6** dissolved.
6. Calculate the change in temperature, ΔT_x, for this experiment.

Results

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[5]

(c) **Determining the change in temperature of water per gram of lithium chloride dissolved**

Using the results from **(a)** and **(b)**, determine the ΔT per gram of LiCl dissolved in water. Indicate relevant workings on your graph as well as any calculations made.

ΔT per gram of LiCl = ……………………… C g^{-1} [2]

[Total: 11]

3 Planning

You are tasked to determine the enthalpy change of reaction of copper and hydrochloric acid, ΔH_r, as shown in the equation below.

$$Cu(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2(g) \qquad \Delta H_r$$

However, copper metal and hydrochloric acid do **not** react together under normal conditions. ΔH_r must therefore be determined by an **indirect** method involving two other reactions and a metal.

One of these reactions is the displacement of copper from aqueous copper(II) chloride, and the other is an acid-metal reaction.

(a) Information of some metals is shown in Table 3.1 below.

Table 3.1

element	relative atomic mass	electrode reaction	$E^{\ominus}$/ V
Ag	107.9	$Ag^+ + e^- \rightleftharpoons Ag$	+0.80
Cu	63.5	$Cu^{2+} + 2e^- \rightleftharpoons Cu$	+0.34
Mg	24.3	$Mg^{2+} + 2e^- \rightleftharpoons Mg$	–2.38
Na	23.0	$Na^+ + e^- \rightleftharpoons Na$	–2.71
Pb	207.2	$Pb^{2+} + 2e^- \rightleftharpoons Pb$	–0.13

Choose a suitable metal from Table 3.1 to be used in the task.

.... [1]

(b) Using the metal you have chosen in **(a)**, construct an energy cycle to show how ΔH_r can be calculated from the enthalpy change of the displacement of copper from aqueous copper(II) chloride, ΔH_1, and the enthalpy change for the acid-metal reaction, ΔH_2.

ΔH_r = ... [2]

(c) Plan and describe a practical procedure, which would enable you to determine ΔH_2, which is exothermic. Your plan must enable you to plot a graph that includes data from the experiment.

You may assume that you are provided with:

- 1.0 mol dm^{-3} hydrochloric acid,
- the metal you have chosen in powder form,
- a stopwatch,
- chemicals and apparatus normally found in a school laboratory.

In your plan, you should include:

- apparatus and chemicals needed,
- a detailed method which provides full instruction, including any calculations you used to work out suitable quantities of the chemicals used,
- a sketch of the graph you expect to obtain,
- an outline of the calculations you would perform to calculate ΔH_2.

You may assume the density of all aqueous solutions are 1.0 g cm^{-3} and the specific heat capacity of the mixture is 4.18 J g^{-1} K^{-1}.

YOU ARE NOT REQUIRED TO CARRY OUT THIS EXPERIMENT.

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(d) Identify one potential safety hazard in this experiment and state how you would minimise this risk.

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[Total: 10]

4 Investigation of some reactions involving transition element ions

You are to explore the reactions of some compounds of an unknown transition element **Z** and determine the identities or structures of a number of different substances.

FA 7	is solid ZO_2.
FA 8	is solid potassium ethanedioate, $K_2C_2O_4$.
FA 9	is a pure solution of **Z**$^{x+}$ which is also the expected product in **(a)**.
FA 10	is a pure sample of a simple hydrocarbon.

(a) Conversion of ZO_2 to Z^{x+}

Perform the tests described in Table 4.1, and record your observations in the table. Test and identify any gases produced.

Table 4.1

test	observations
Add all of the solid **FA 8** into a boiling tube. Add 15 cm^3 of **FA 2** into this boiling tube. Gently warm the boiling tube and gently stir the mixture with the thermometer, until the mixture's temperature reaches about 60 ^{o}C. Turn off the Bunsen flame. Use a spatula to add **FA 7** to the mixture, until no further change is seen. After each addition, gently stir the mixture with the thermometer and observe any changes in the mixture's temperature. When you think that the reaction is complete, stop adding **FA 7**. Filter the mixture into another boiling tube. Leave the filtrate to stand. Keep this filtrate for use in **(b)**.	

(i) Explain how you have decided to stop adding **FA 7** at the point you have chosen. Support your answer using your observations from Table 4.1.

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(ii) What two conclusions can you infer about the nature of the reaction occurring between **FA 7** and **FA 8**? Support each conclusion using your observations from Table 4.1.

Conclusion 1 ……………………………………………………………………………………

Evidence …………………………………………………………………………………………

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Conclusion 2 ……………………………………………………………………………………

Evidence …………………………………………………………………………………………

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[2]

(b) Analysis of the filtrate from (a) and FA 9

You will analyse separate samples of the filtrate from **(a)** and **FA 9** using the reagents:

- aqueous ammonia, and
- aqueous sodium hydroxide

(i) In Table 4.2 below, describe how you would carry out the tests on separate portions of the filtrate from **(a)** and **FA 9**.

Carry out the tests and record your observations in Table 4.2.

Table 4.2

test	observations for filtrate from **(a)**	observations for **FA 9**

[1]

(ii) Based on your observations in Table 4.2, what is the identity of the transition metal ion present in **FA 9**? Suggest why there was a difference in observations when you added aqueous sodium hydroxide in **FA 9**, compared to the filtrate from **(a)**.

Ion present ………………………

Suggestion for difference …………………………………………………………….............

………………………………………………………………………………………………..……..

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(c) **Analysis of FA 10**

Before starting this analysis, ensure your Bunsen burner is turned off.

(i) Perform the tests described in Table 4.3, and record your observations in the table.

Table 4.3

	test	Observations
1.	Add 5 cm^3 of deionised water and 1 drop of **FA 10** into a test-tube. Add aqueous bromine dropwise with shaking, until no further change is seen.	
2.	Add 5 cm^3 of **FA 2** and 1 drop of **FA 10** into a test-tube. Add aqueous potassium manganate(VII), dropwise with shaking, until no further change is seen.	
3.	Add 5 cm^3 of aqueous sodium hydroxide and 1 drop of **FA 10** into a test-tube. Add aqueous potassium manganate(VII), dropwise with shaking, until no further change is seen.	

[8]

(ii) The main organic product formed in test 3 in Table 4.3 has the molecular formula $C_5H_{10}O_2$.

What is the molecular formula of **FA 10**? Explain your reasoning based on your observations in tests 1 and 3 in Table 4.3.

Molecular formula …………………………..

Explanation ………………………………………………………………….…….………….

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(iii) Draw the structure of **FA 10**.

[1]

(d) Planning

Consider the following organic compounds.

3-hydroxybenzaldehyde phenol 2-phenylethanal

Plan an investigation, using test-tube reactions involving reagents containing **transition elements other** than those in **(c)**, which would allow you to identify each of these three organic compounds.

You are provided with either pure liquid samples of these compounds or samples containing the compounds dissolved in an inert organic solvent.

Each compound should be identified by at least one positive test result. It is **not** sufficient to identify a compound simply by eliminating all the others.

Your plan should include:

- details of the reagents and conditions to be used,
- an outline of the sequence of steps you would follow,
- an explanation of how you would analyse your results in order to identify each compound.

Once a compound has been clearly identified, your plan should concentrate on distinguishing the remaining compounds.

YOU ARE NOT REQUIRED TO CARRY OUT THIS EXPERIMENT.

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[Total: 19]

Qualitative Analysis Notes
[ppt. = precipitate]

(a) Reactions of aqueous cations

cation	***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)	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 giving dark green solution	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

(b) Reactions of aqueous 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 pale 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 A*l* foil
nitrite, NO_2^-(aq)	NH_3 liberated on heating with OH^-(aq) and A*l* foil; NO liberated by dilute acids (colourless NO → (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)	SO_2 liberated on warming with dilute acids; gives white ppt. with Ba^{2+}(aq) (soluble in dilute strong acids)

(c) 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
sulfur dioxide, SO_2	turns aqueous acidified potassium manganate(VII) from purple to colourless

(d) Colour of halogens

halogen	***colour of element***	***colour in aqueous solution***	***colour in hexane***
chlorine, Cl_2	greenish yellow gas	pale yellow	pale yellow
bromine, Br_2	reddish brown gas / liquid	orange	orange-red
iodine, I_2	black solid / purple gas	brown	purple