TEMASEK JUNIOR COLLEGE

2017 JC2 PRELIMINARY EXAMINATIONS
HIGHER 2

CANDIDATE NAME	
CIVICS GROUP	/
CENTRE NO. / INDEX NO.	/

CHEMISTRY **9729/04**

Paper 4 Practical **28 August 2017**

2 hours 30 minutes

Candidates answer on the Question Paper.

READ THESE INSTRUCTIONS FIRST

Write your Civics Group and name 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 14 and 15.
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	/ 15
2	/ 24
3	/ 16
Total	/ 55

This document consists of 15 printed pages.

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

1 **Determination of change in oxidation number of a transition metal ion, M^{2+}**

You are to determine, by titration, the change in oxidation number of a transition metal ion, $\mathbf{M}^{2+}$, when reacted with acidified potassium manganate(VII).

FA 1 is 0.0200 mol dm^{-3} potassium manganate(VII), $KMnO_4$
FA 2 is 0.0470 mol dm^{-3} transition metal salt, $\mathbf{M}SO_4$
FA 3 is 1.00 mol dm^{-3} sulfuric acid, H_2SO_4

(a) Method

(i)
1. Fill the burette with **FA 1.**
2. Using a pipette, transfer 25.0 cm^3 of **FA 2** into the conical flask.
3. Using a measuring cylinder, transfer 25.0 cm^3 of **FA 3** to the same conical flask.
4. Carry out as many accurate titrations as necessary to obtain consistent results. Add **FA 1** until the contents of the conical flask turns a permanent pale pink colour.
5. Record below, in a table form, all of your burette readings and the volume of **FA 1** added in each accurate titration.

Results

[6]

(ii) From your titrations, obtain a suitable volume of **FA 1** to be used in your calculations. Show clearly how you obtained this volume.

25.0 cm^3 of **FA 2** required ______________ cm^3 of **FA 1** [1]

(b) Calculations

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

(i) Calculate the amount of potassium manganate(VII) present in the volume of **FA 1** calculated in **(a)(ii)**.

amount of $KMnO_4$ = ______________________________ [1]

(ii) Determine the amount of **M**SO_4 in 25.0 cm^3 of **FA 2**.

amount of **M**SO_4 in 25.0 cm^3 = ______________________________ [1]

(iii) Use your answer to **(b)(i)** and **(b)(ii)** to calculate the number of moles of **M**SO_4 that react with 1 mole of $KMnO_4$

amount of **M**SO_4 = ______________________________ [1]

(iv) Two possible equations for the reaction of acidified $KMnO_4$ with **M**SO_4 are shown below:

Equation 1: $2KMnO_4 + 10\mathbf{M}SO_4 + 8H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5\mathbf{M}_2(SO_4)_3 + 8H_2O$
Equation 2: $2KMnO_4 + 5\mathbf{M}SO_4 + 8H_2SO_4 \rightarrow K_2SO_4 + 2MnSO_4 + 5\mathbf{M}(SO_4)_2 + 8H_2O$

State and explain which of the above two equations is consistent with your answer in **(b)(iii)**.

____

____

____

____ [1]

(v) Use your answer in **(b)(iv)** to state the oxidation number of the transition metal **M** in the product of the reaction.

[1]

(c) **(i)** A student suggested that using a burette to measure 25.0 cm^3 of **FA 2** would give a more accurate result than using a pipette. The percentage error of a 25.0 cm^3 pipette is 0.24%.

Calculate the percentage error of using a burette and deduce if the above claim by the student is correct.

[2]

(ii) Another student decided to use a 25.0 cm^3 pipette instead of a measuring cylinder to measure the volume of **FA 3** in **Step 3**.

State and explain whether this alteration will improve the accuracy of the experimental results.

[1]

[Total: 15]

2 **Determination of the enthalpy change of neutralisation, ΔH_n**

You are to determine the enthalpy change for the neutralisation reaction given below.

$$HA(aq) + NaOH(aq) \rightarrow NaA(aq) + H_2O(l)$$

FA 4 is 1.80 mol dm^{-3} HA
FA 5 is aqueous sodium hydroxide, NaOH

(a) Method

Read through the instructions carefully and prepare a table below for your results before starting any practical work.

1. Support the styrofoam cup in the 250 cm^3 beaker.
2. Rinse and fill the burette with **FA 4**.
3. Use the measuring cylinder to transfer 25 cm^3 of **FA 5** into the styrofoam cup.
4. Place the thermometer in the styrofoam cup and record the temperature of the solution. Tilt the cup if necessary to ensure the thermometer bulb is fully immersed.
5. Run 5.00 cm^3 of **FA 4** into the cup. Stir, and record the new temperature of the solution and the volume of **FA 4** added.
6. Run a second 5.00 cm^3 of **FA 4** into the cup. Stir and record the new temperature and the total volume of **FA 4** added.
7. Continue adding **FA 4** in 5.00 cm^3 portions. Stir and record each new temperature and total volume of **FA 4** until a total of 45.00 cm^3 has been added.

Results

[2]

(b) **(i)** Plot a graph of temperature (y-axis) against total volume of **FA 4** added (x-axis) on the grid below. The temperature axis should allow you to include a point at least 2 °C greater than the maximum temperature recorded.

Draw two best-fit lines connecting all the plotted points with

- an increasing trend
- a decreasing trend.

[3]

(ii) Extrapolate the two lines until they cross.
The intersection gives the maximum temperature, T_{max}, at equivalence point.
Use your graph to determine the following and show clearly on your graph how you obtained these answers.

- Maximum temperature at the equivalence point, $T_{max,}$
- Maximum temperature change at the equivalence point, $\Delta T_{max.}$
- Total volume of **FA 4** added at the equivalence point, $V_{eq.}$

T_{max} = ____________________

ΔT_{max} = ____________________

$V_{eq.}$ = ____________________

[3]

(c) Explain the shapes of your graph lines before the equivalence point and after the equivalence point.

(i) Before the equivalence point

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[2]

(ii) After equivalence point

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____

____

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[1]

(d) **Calculations**

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

(i) Calculate the number of moles of HA present in the volume of **FA 4** recorded in **(b)**.

Amount of HA = ____________________

(ii) Using your answers in **(b)**, calculate the heat energy produced when **FA 4** neutralised 25 cm^3 of sodium hydroxide.
(Assume that **4.2 J** of heat energy changes the temperature of 1.0 cm^3 of solution by 1 °C.)

Heat energy produced = ____________________

(iii) Calculate the enthalpy change of neutralisation, in kJ mol^{-1}, for the reaction below.

$$HA(aq) + NaOH(aq) \rightarrow NaA(aq) + H_2O(l)$$

Enthalpy change = ____________________

[6]

(e) Apart from using a thermometer calibrated to a greater level of precision, suggest one other improvement that could be made to the **method** carried out in **(a)**.

____

____

____

[1]

Planning

The enthalpy change of solution of solid NaOH can be calculated using the enthalpy change of neutralisation of aqueous NaOH with aqueous HC*l*, ΔH_1 and the enthalpy change of reaction of solid NaOH with aqueous HC*l*, ΔH_2.

(f) Given that the enthalpy change of neutralisation of aqueous NaOH with aqueous HC*l* is –57.0 kJ mol^{-1}, construct an energy cycle and show how it can be used to determine the enthalpy change of solution of NaOH.

[1]

(g) You are to plan an experiment to determine the enthalpy change of reaction of solid NaOH with aqueous HC*l*, ΔH_2. You are provided with the following reagents and the usual laboratory apparatus.

Reagents : 50 cm^3 1 mol dm^{-3} HC*l* solution
sodium hydroxide solid

Your plan should include

- calculation to show the appropriate mass of solid sodium hydroxide to be used.
- a sequence of numbered steps, the details of the experimental procedure including the measurements to be taken and tabulation of measurements and results.
- calculation of the enthalpy change of reaction of solid NaOH with HC*l* (aq).

(Assume that **4.2 J** of heat energy changes the temperature of 1.0 cm^3 of solution by 1 °C.)
[Ar Na: 23.0, H:1.0; O:16.0]

[5]
[Total:24]

3 You are provided with the solid **FA 6** and solution **FA 7**.

You are to perform the tests below and record your observations in the spaces provided. Your answers should include

- details of colour changes and precipitates formed;
- the names of any gases evolved **and** details of the test used to identify each one.

You should indicate clearly at what stage in a test a change occurs.

If it appears that no reaction has taken place this should be clearly recorded.

Rinse and reuse test-tubes where possible.

Marks are **not** given for chemical equations.

No additional or confirmatory tests for ions present should be attempted.

Candidates are reminded that definite deductions may be made from tests where there appears to be no reaction.

(a) **FA 6** contains one cation and one anion.

	Test	*Observation*
(i)	To half a spatula-full of **FA 6** in a test-tube add excess dilute sulfuric acid. Keep the solution for test **(iii)** and **(iv)**.	
(ii)	Place a spatula-full of **FA 6** in a test-tube and heat strongly.	
(iii)	To 1 cm depth of the solution from **(i)** in a test-tube, add a few drops of aqueous sodium hydroxide Then add excess aqueous sodium hydroxide.	

(iv)	To 1 cm depth of the solution from **(i)** in a test-tube, add a few drops of aqueous ammonia. Then add excess aqueous ammonia.	

The cation present in **FA 6** is ______________________

The anion present in **FA 6** is ______________________

FA 7 contains one cation and two anions.

	Test	*Observations*
(v)	To 1 cm depth of **FA 7** in a test-tube, add a few drops of aqueous sodium hydroxide. Then add excess aqueous sodium hydroxide. Warm the mixture.	
(vi)	To 1 cm depth of **FA 7** in a test-tube, add a few drops of aqueous ammonia Then add excess aqueous ammonia.	
(vii)	To 1 cm depth of **FA 7** in a test-tube, add aqueous silver nitrate, followed by aqueous ammonia.	
(viii)	To half a spatula-full of **FA 6** in a test-tube, add 3 cm depth of **FA 7**.	
	Then add 1 cm depth of aqueous sodium thiosulfate.	

One anion present in **FA 7** is

With reference to tests **(v)**, **(vi)** and **(viii)**, suggest the identity of the cation present in **FA 7**.

The second anion is suspected to be the sulfate ion.

(ix) Suggest a test to verify the presence of sulfate ion in **FA 7**. Carry out the test and record your results in the space below.

[11]

(b) **FA 8** is a solution that contains the Cr^{3+}, Mg^{2+} and Cl^{-} ions.

Plan a sequence of steps by which the three ions could be separated so that each ion is present in a separate precipitate. For each of the steps, you are to specifiy the location of the ions.

You may assume that the usual bench reagents and apparatus are available for use.

[5]

[Total: 16]

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 anions

anion	*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 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)	SO_2 liberated 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) Colours 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