NATIONAL JUNIOR COLLEGE
SH 2 Year – End Practical Examination
Higher 2

CANDIDATE NAME			
SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY 9729/04

Paper 4 Practical
Candidate answer on the Question paper.

Tuesday 20 August 2019
2 hours 30 minutes

READ THE INSTRUCTIONS FIRST
Write your identification number and name. Circle 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, highlighters, 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 19 and 20.

At the end of the examination, submit the question paper.
The number of marks is given in brackets [ ] at the end of each question or part question.

Shift			
1	**2**		**3**
Laboratory			
CM41	**CM42**	**CM43**	**CM44**
PH31	**PH32**	**PH33**	
BI23	**BI24**		
For Examiner's Use			

1	**/ 12**
2	**/ 21**
3	**/ 14**
4	**/ 8**
Total	**/ 55**

This document consists of **19** printed pages and **1** blank page.

1 Determination of the solubility product of calcium iodate(V)

When solid calcium iodate(V) is added to water to form a saturated solution, an equilibrium between the undissolved salt and its aqueous ions is established.

$$Ca(IO_3)_2\,(s) \rightleftharpoons Ca^{2+}\,(aq) + 2IO_3^-\,(aq)$$

The solubility product, K_{sp} , of calcium iodate(V) is expressed as follows.

$$K_{sp} = [Ca^{2+}(aq)]\,[IO_3^-(aq)]^2$$

The solubility product can be found by determining the equilibrium concentration of IO_3^- ions in a saturated solution of calcium iodate(V) through a redox titration.

Iodate(V) ions, IO_3^-, react with iodide ions according to the following equation.

$$IO_3^-\,(aq) + 5I^-(aq) + 6H^+\,(aq) \longrightarrow 3I_2\,(aq) + 3H_2O\,(l)$$

The iodine produced in this reaction may be titrated against sodium thiosulfate using starch solution as indicator. Thiosulfate ions react with iodine according to the following equation:

$$2S_2O_3^{2-}(aq) + I_2(aq) \longrightarrow S_4O_6^{2-}(aq) + 2I^-(aq)$$

In this question, you will prepare a saturated solution of calcium iodate(V) to carry out the redox titration. Using the experimental results, you will determine the solubility product of calcium iodate(V).

You are provided with:
FA 1 is solid calcium iodate(V), $Ca(IO_3)_2$

FA 2 is 0.05 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$

FA 3 is 0.50 mol dm^{-3} potassium iodide, KI

FA 4 is 0.50 mol dm^{-3} sulfuric acid, H_2SO_4

FA 5 is starch indicator

Preparation of a saturated solution of calcium iodate (V), FA 6

(a) Procedure

1. Use a 100 cm^3 measuring cylinder to transfer 80.0 cm^3 of deionised water into a 250 cm^3 beaker.

2. Transfer all **FA 1** from the weighing bottle into the beaker. Stir for 1 to 2 minutes and leave to stand for **5 minutes**. There will be some $Ca(IO_3)_2$ solids left undissolved.

3. Use a 0.2 °C division thermometer, record the temperature of the solution in the beaker.

4. To remove the undissolved solids, filter the saturated solution into another clean and **dry** 250 cm^3 beaker using a **dry** filter paper and **dry** funnel. Label this solution as **FA 6**.

Titration

(b) Procedure

(i) **1.** Fill a burette with **FA 2**.

2. Pipette 10.0 cm^3 of **FA 6** into a conical flask.

3. Use a 10 cm^3 measuring cylinder to add 5.0 cm^3 of **FA 3**, followed by 5.0 cm^3 of **FA 4** to the same conical flask and swirl quickly.

4. Titrate the iodine in the conical flask with **FA 2** until the brown colour of the iodine becomes pale yellow.

5. Add about 10 drops of starch solution to the flask and continue adding **FA 2** until the blue-black colour just disappears.

6. Repeat the titration as many times as you think necessary to obtain consistent results. Record your titration results in the space below.

Results

Temperature of the solution in the beaker = …….. ^oC

		1	2	
Final burette reading	**/ cm^3**			
Initial burette reading	**/ cm^3**			
Volume of FA 2 used	**/ cm^3**			

[1]Record the temperature of the solution in the beaker
[1] Records all burette readings to 2 d.p including a(ii). (MMO)
[1] Has at least 2 titre values ± 0.10 cm^3 (MMO)
[1] Table has appropriate headings and units (PDO)

[-1] Incorrect calculation for volume of FA2

[4]

(ii) From your titres, obtain a suitable volume of **FA 2** to be used in your calculations. Show clearly how you obtained this volume.

Average vol of **FA 2** used = (x.00 +.00)/2 =x.00 cm^3 (round to 2 d.p.) **[1]**

* Do not award marks if inconsistent values used
* Do penalise if no working

10.0 cm^3 of **FA 6** produced an amount of iodine which required ……...… cm^3 of **FA 2**.
[1]

(c) Calculations

Show your working and appropriate significant figures in the final answer to **each** part.

(i) Calculate the number of moles of $S_2O_3^{2-}$ in the volume of **FA 2** recorded in **b(ii)**, and hence determine the molar concentration of IO_3^- ions in **FA 6**.

Amt of $S_2O_3^{2-}$ = (ans from b(ii)/1000) x 0.05 = A mol **[1]**

$$\frac{\eta_{IO_3^-}}{\eta_{S_2O_3^{2-}}} = \frac{1}{6}$$

Amt of IO_3^- = $\frac{1}{6} \times A$ = B mol

$[IO_3^-]$ = $B \times \frac{1000}{10.0}$ = c mol dm^{-3} **[1]** **(Allow ecf)**

number of moles of $S_2O_3^{2-}$ =……..

concentration of IO_3^- ions in **FA 6** =……..

[2]

(ii) Determine the molar concentration of Ca^{2+} in **FA 6** and hence, calculate the solubility product, K_{sp}, of calcium iodate(V), stating the units.

$$\frac{\eta_{Ca^{2+}}}{\eta_{IO_3^-}} = \frac{1}{2}$$

$[Ca^{2+}]$= ½ $[IO_3^-]$ = ½ c mol dm^{-3} **[1]** **(Allow ecf)**

$K_{sp} = [Ca^{2+}(aq)]\,[IO_3^-(aq)]^2$
$= [½\ C]\,[C]^2$
$= ½\ C^3$ $mol^3\ dm^{-9}$ **[1] (Allow ecf)**
(Do not award the mark if the units is wrong)

concentration of Ca^{2+} ions in **FA 6** = ……..

solubility product of $Ca(IO_3)_2$ = ……..

[2]

(d) Explain why it was necessary to use the **dry** apparatus (e.g. beaker, filter paper and funnel) in the preparation of **FA 6**, and what effect failing to do it would have on the titre values?

To prevent the dilution of the saturated **FA 6** solution which results in lesser amount of ……..

IO_3^- reacted during titration and hence smaller titre value **[1]**

(Do not award mark if there is no mention to the change in the titre value or change in conc of FA 6 or IO_3^-.)

[1]

(e) A literature value for the solubility product of calcium iodate(V) is found to be 6.15×10^{-6} at 20 °C.

State a possible reason for the difference in the K_{sp} value that you have calculated and suggest an improvement that might allow a value closer to the literature value to be obtained.

If the **calculated K_{sp} > literature K_{sp} value**, the explanation is as follow:

The experiment is not carried out at 20 ^{o}C **[1]**.
$Ca(IO_3)_2$ (s) ⇌ Ca^{2+} (aq) + $2IO_3^-$ (aq)
Hence, the equilibrium position shifted to the right.

Use a thermostatically controlled **water bath maintained at 20 ^{o}C** during the preparation of **FA 6** before carrying out the filtration **[1]**.

or

If the **calculated K_{sp} < literature K_{sp} value**, the explanation is as follow:

The **salt has not dissolve to form a saturated solution** or **reach equilibrium with its dissolved ions**. **[1]**

Leave the mixture to stand for longer period and use a thermostatically controlled **water bath to maintain at 20 ^{o}C** for the salt solution to reach equilibrium / saturation. **[1]**

[Total: 12]

2 Determination of the enthalpy change of neutralisation, ΔH_n

FA 7 is a solution of HCl of unknown concentration
FA 8 is a solution of 1.0 mol dm^{-3} of NaOH

In this question, you will carry out a series of experiments where different volumes of **FA 7** and **FA 8** are mixed together.

You will determine the temperature change of the reaction mixture, ΔT, of each experiment and then analyse your results graphically in order to determine the

- concentration of HCl in **FA 7**
- maximum temperature change, ΔT_{max}
- value for the enthalpy change of neutralisation, ΔH_n

(a) Determining the change in temperature for a series of reactions between FA 7 and FA 8

(i) Experiment 1

1. Place a Styrofoam cup inside a second Styrofoam cup held in a 250 cm^3 beaker to prevent it from tipping over.

2. Using a measuring cylinder, transfer 20.0 cm^3 of **FA 7** into the Styrofoam cup.

3. Measure the temperature of **FA 7** in the Styrofoam cup. Record the initial temperature of the solution of **FA 7** as $\mathbf{T_{FA\,7}}$.

4. Rinse and dry the thermometer.

5. Measure 50.0 cm^3 of **FA 8** using another measuring cylinder. Record the initial temperature of the solution of **FA 8** as $\mathbf{T_{FA\,8}}$.

6. Transfer the **FA 8** into the cup containing **FA 7**. Stir and record the maximum temperature of the reaction as $\mathbf{T_{max}}$.

7. Rinse and dry the Styrofoam cup and thermometer.

Experiment 2
Repeat steps 2 to 7 using 50.0 cm^3 of **FA 7** and 20.0 cm^3 **FA 8**.

Experiments 3 to 6
Carry out **four** further experiments to investigate how the $\mathbf{T_{max}}$ changes with different volumes of **FA 7** and **FA 8**. In each case, the total volume of the reaction mixture must be 70.0 cm^3 and the volume of each reagent should not be less than 20.0 cm^3.

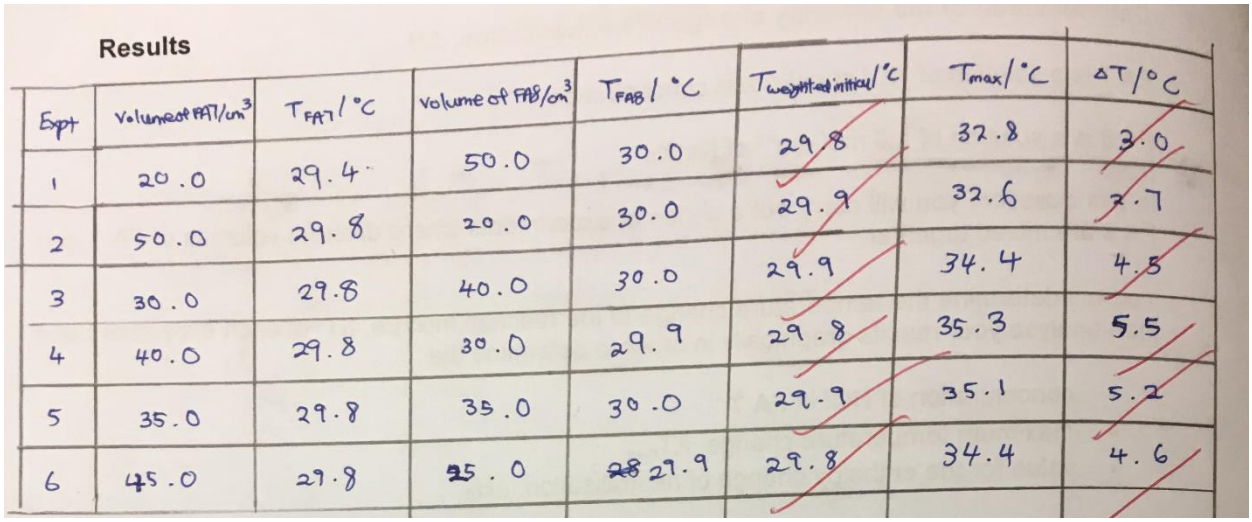
In an appropriate format in the space provided on next page, record
- all measurements of volumes used,
- all temperatures measured, $T_{weighted\ initial}$ and ΔT

$\mathbf{\Delta T = T_{max} - T_{weighted\ initial}}$

$$\mathbf{T_{weighted\ initial}} = \frac{(Volume\ of\ FA\ 7 \times T_{FA\ 7}) + (Volume\ of\ FA\ 8 \times T_{FA\ 8})}{Volume\ of\ FA\ 7 + Volume\ of\ FA\ 8}$$

Result

Expt	Vol of **FA 7** /cm^3	Vol of **FA 8** /cm^3	$T_{FA\,7}$ / °C	$T_{FA\,8}$ / °C	$T_{weighed\ initial}$ / °C	T_{may} / °C	ΔT/ °C
1							
2							
3							
4							
5							
6							



Results

Expt	Volume of FA7/cm^3	T_{FA7}/°C	Volume of FA8/cm^3	T_{FA8}/°C	$T_{weighted\ initial}$/°C	T_{max}/°C	ΔT/°C
1	20.0	29.4	50.0	30.0	29.8	32.8	3.0
2	50.0	29.8	20.0	30.0	29.9	32.6	2.7
3	30.0	29.8	40.0	30.0	29.9	34.4	4.5
4	40.0	29.8	30.0	29.9	29.8	35.3	5.5
5	35.0	29.8	35.0	30.0	29.9	35.1	5.2
6	45.0	29.8	25.0	~~28~~ 29.9	29.8	34.4	4.6

[1] Appropriate header with units
[1] Recording to correct precision
[1] Correct calculation of $T_{weighted\ initial}$ and ΔT_{max} in 1 d.p
[1] Proper spread of the choice of the volume used for the other 4 expts
[-1] Missing any of the experiment results
[-1] Missing the recording of $T_{weighted\ initial}$
[-1] Vol of either FA7 or FA8 used is less than 20.0 cm^3
[-1] Recording of data is <u>NOT IN ONE</u> table.
[-1] Missing T_{FA7} and/or T_{FA8}

[4]

(ii) Plot a graph of ΔT (*y*–axis) against volume of **FA 7** used (*x*–axis) on the grid in Fig. 2.1 using the data you have obtained in **2a(i)**.

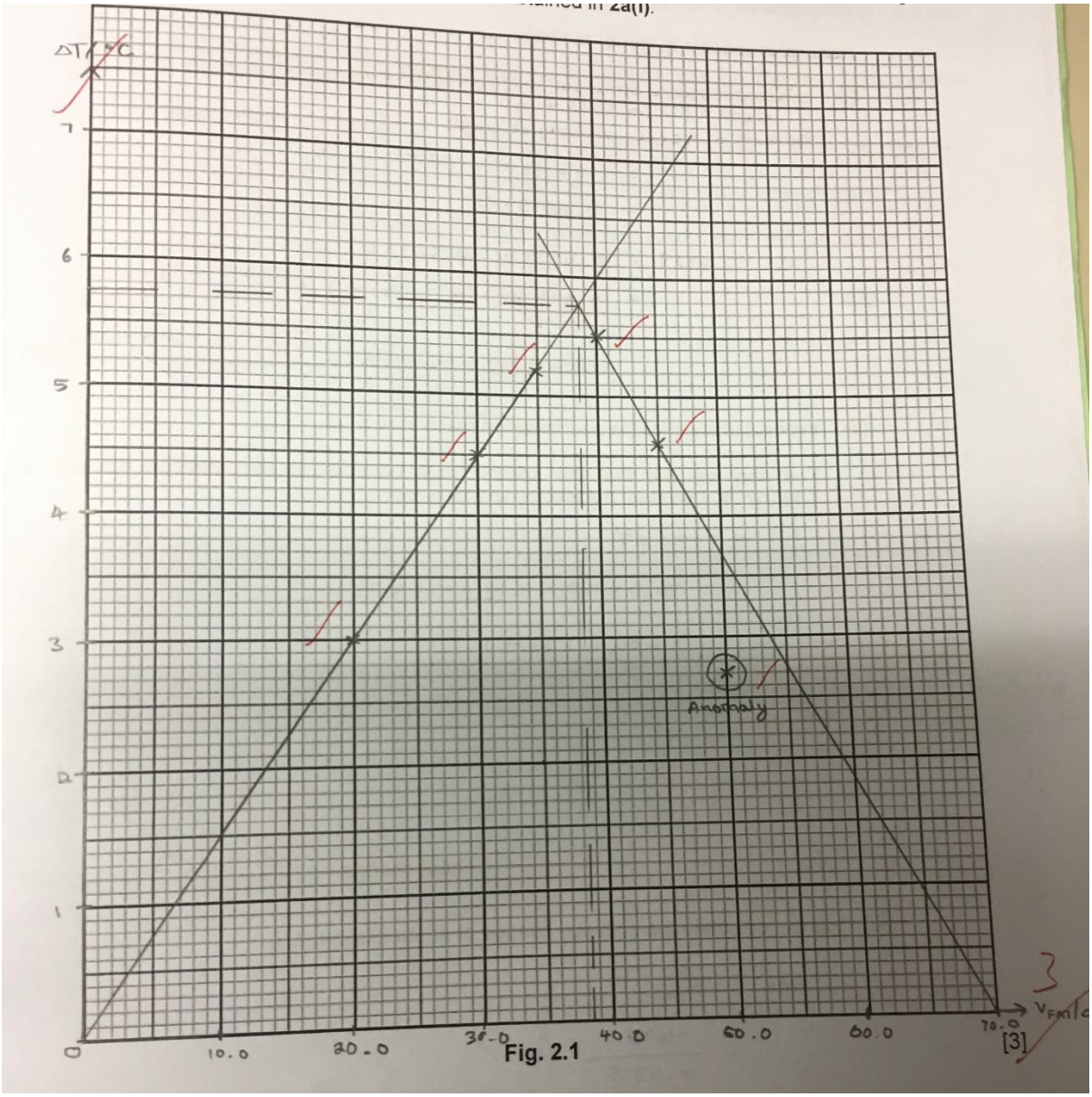


Fig. 2.1

Fig. 2.1 [3]

[1] - Label of the axis with units and appropriate scale
[1] - Points plotted within half a square of 'x'
[1] –The line of best fit must include two points at x= 0 and x = 70
Note: ΔT_{max} should be higher than any of the plotted points.
[-1] if ΔT_{max} is lower than the plotted points .
Plotted points covers more than 50% of grids in both *x* & *y* axis

(iii) Draw two best-fit straight lines, the first should be drawn using the plotted points where ΔT is increasing and the second should be drawn using the plotted points where ΔT is decreasing. Extrapolate (extend) both lines until they intercept.

[1]

[1] - Line of best fit to pass through the plotted points

(iv) From your graph in Fig. 2.1, determine the maximum temperature change, ΔT_{max}, and the volume, V_{max}, of **FA 7** required to obtain this.

Correct reading off the ΔT_{max} value from the graph [1] (ignore precision)

Correct reading off the V_{max} value from the graph [1] (ignore precision)

ΔT_{max} = ……^{o}C V_{max} = ……cm^3 [2]

(b) Calculation

Show your working and appropriate significant figures in the final answer to **each** part.

Using your answers in **2a(iv)**, calculate

(i) the concentration, in mol dm^{-3}, of HC*l* in **FA 7**.

$V_{NaOH} = 70 - V_{max}$ = A cm^3
Amt of NaOH = A/1000 x 1.0 = B mol **[1]**

Amount of HC*l* = B mol
Conc of HC*l* = B / (V_{max}/1000) = C mol dm^{-3} **[1] (Allow ecf)**

concentration of HC*l* in **FA 7** = …… [2]

(ii) the heat change for the neutralisation at ΔT_{max}.

You may assume that the specific heat capacity of the reaction mixture is 4.18 J g^{-1} K^{-1} and that the density is 1.00 g cm^{-3}.

$q = mc\Delta T_{max}$ = 70 x 4.18 x ΔT_{max} = D J

heat change = –D J **[1] (Accept if heat change value is positive)**

heat change = …… [1]

(iii) Hence, calculate the enthalpy change of neutralisation, ΔH_n.

Amount of H_2O = Amount of NaOH = Amount of HC*l* = B mol

ΔH_{neut} = −D / B = −E kJ mol^{-1} **[1] (Must have the negative sign to award the mark) (Allow ecf)**

ΔH_n = …… [1]

(c) In another similar experiment, 1.0 mol dm^{-3} aqueous ammonia was used instead of 1.0 mol dm^{-3} NaOH. A graph of maximum change in temperature, ΔT, against volume of **FA 7** was plotted.

Suggest how would the ΔT_{max} and volume, V_{max}, of **FA 7** from this experiment be compared to your result obtained in **2a(iv)** .

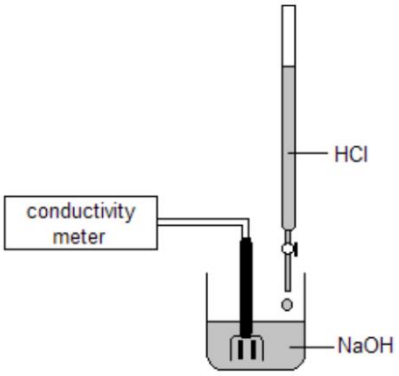
Lower temperature rise, ΔT_{max}, as **some heat released is used to dissociate** the weak ……
base completely. **[1]**
(Do not accept rate of reaction is less vigorous and heat lost or less water formed or the reaction is less exothermic)

……
V_{max} is the same as same number of moles of HC*l* is needed to react with the aqueous
……
NH_3 since the reacting mole ratio remains the same. **[1]**
……[2]

(d) A student employed another method to determine the concentration of the HC*l* in **FA 7** through the use of conductometry. Conductometry is the measurement of the electrolytic conductivity to monitor the progress of a chemical reaction due to ions being produced or reacted away. The equivalence point can then be determined for the acid – base reaction by plotting the conductivity against the volume of the HC*l* added.

$$H^+ + OH^- \longrightarrow H_2O$$

The following apparatus were set up.



The student measured the conductivity of the solution in the beaker with each addition of a small fixed volume of HC*l* and obtained the following graph.

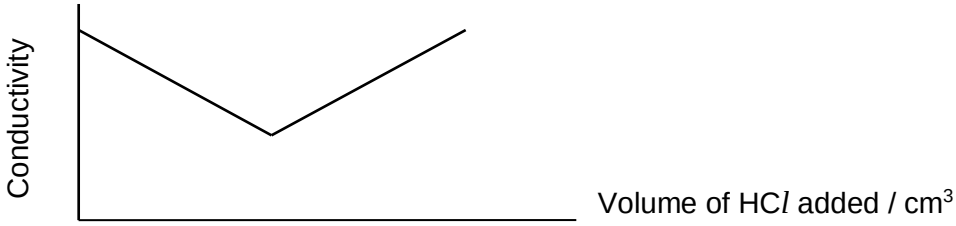
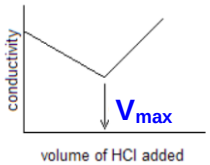


Fig. 2.2

(i) Indicate on the graph (Fig. 2.2), the point which marks the volume of HC*l* needed for complete reaction. [1]
V_{max} is the volume of HC*l* that corresponds to the minimum conductivity **[1]**



(ii) Explain the shape of the graph in Fig. 2.2.

The conductivity decreases as more HC*l* is added. This is due to the **formation of** ……
water from H+ and OH^-, which **decreases the total amount of ions** in water and ……
hence conductivity. **[1]**
……
The conductivity decreases to the lowest point where the equivalence volume of ……
HC*l* is reached, as **all the NaOH has reacted** with the HC*l* .Thus. that is the ……
minimum amount of ions that can be present and gives the lowest conductivity. **[1]**
……
After the equivalence point, **no more neutralisation** occurs. Any HC*l* that is added ……
dissociates and contributes to the total amount of ions in water, thus ……
increasing the conductivity. **[1]**
……[3]

(iii) With reference to your experiment in **2(a)**, suggest which method (calorimetry or conductometry) is more accurate for the determination of the concentration of HC*l* in **FA 7**.

Conductometry is more accurate. For conductometry, there is **no heat loss to the** ……
surroundings.

Explanation 1: For **calorimetry, the heat loss to the surroundings** will lower the ……
ΔT_{max} and hence render the volume of HC*l* needed for complete neutralisation ……
inaccurate

Explanation 2: For **calorimetry, the heat loss to the surroundings** will affect each ΔT plotted point, resulting in inaccurate two best-fit straight lines drawn to determine ΔT_{max} and hence volume of HC*l* needed for complete neutralisation will be inaccurate.
[1]
……[1]

[Total: 21]

3 Identification of ions

FA 9 is a solution containing a mixture of two salts.

You are to perform the tests described in Table 3.1 and record your observations in the table.

In all tests, the reagents should be added gradually until no further change is observed unless you are instructed otherwise. You should indicate clearly at which stage in a test a change occurs, recording your observations alongside the relevant tests.

The volumes given below are approximate and should be estimated rather than measured, unless otherwise stated. If there is no observable change, write **no observable change**.

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

Table 3.1

	Test	*Observation*
(a)	Place about 3 cm depth of **FA 9** in a test-tube, add equal volume of aqueous sodium hydroxide. Warm the contents in the tube.	White, off-white, buff or light brown ppt. **[1]** Moist red litmus did not turn blue or no alkaline gas produced. **[1]** Ppt turned browned or darkened. **[1]**
(b)	Filter the mixture from **(a)** and collect the filtrate in a test tube. Label the filtrate as **FA 10** and retain it for tests **3(c)** and **3(d)**. Leave the residue in the filter paper and observe it again after 5 minutes.	White, off-white, buff, light brown or brown residue. [awarded once either here or in test (a) but not in both] Colourless filtrate obtained. **[1]** Residue turned brown or darkened. [awarded once either here or in test (a) but not in both]
(c)	Place 2 cm depth of **FA 10** in a test-tube and add nitric acid until no further change is seen. Label the solution as **FA 11** and retain it for test **3(e)**.	White ppt formed **[1]** Dissolved in excess nitric acid to give a colourless solution. **[1]**
(d)	Place 1 cm depth of **FA 10** in a test-tube. Add half a spatula of zinc powder. Warm the contents in the tube cautiously.	Colourless and pungent gas evolved **[1]** which turned moist red litmus paper blue. **[1]**
(e)	Place 2 cm depth of **FA 11** in a test-tube, add equal depth of aqueous ammonia. Add excess dilute nitric acid followed by aqueous silver nitrate.	White ppt formed**[1]** Soluble/dissolved in excess aqueous ammonia to form a colourless solution. **[1]** On adding HNO_3 acid, no gas evolved**[1]** White ppt formed **[1]** Dissolved in excess nitric acid to give a colourless solution. **[1]** On adding silver nitrate, no ppt observed. **[1]**

	Test	*Observation*
(f)	Place 1 cm depth of **FA 9** in a test-tube. Add dilute hydrochloric acid followed by aqueous barium chloride.	On adding acid, no observable change/ no gas liberated/ no ppt formed. **[1]** On adding barium chloride, white ppt formed. **[1]**

[6]

[6] – **obtain 13 points**
[5] – **obtain 11 points**
[4] – **obtain 9 points**
[3] – **obtain 7 points**
[2] – **obtain 5 points**
[1] – **obtain 3 points**

(g) **(i)** Identify the **two** cations and **two** anions present in **FA 9.**

Mn^{2+} **[1]** Zn^{2+} **[1]**

cation 1: …… cation 2: ……

SO_4^{2-} **[1]** NO_3^- **[1]**

anion 1: …… anion 2: ……

[4]

(ii) Write equations, with state symbols, to illustrate the observations in **3(c)**.

$[Zn(OH)_4]^{2-}(aq) + 2H^+(aq) \rightleftharpoons Zn(OH)_2(s) + 2H_2O(l)$ **[1]**

colourless filtrate white ppt

……

$Zn(OH)_2(s) + 2H^+(aq) \rightleftharpoons Zn^{2+}(aq) + 2H_2O(l)$ **[1]**

white ppt colourless solution

……

……[2]

(iii) Predict what will happen when solid ammonium nitrate is added to **FA 9** followed by aqueous ammonia.

$NH_4NO_3 \rightarrow NH_4^+ + NO_3^-$

……

$NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ ----(1)

……

The dissociation of ammonium nitrate produces NH_4^+ which suppressed the dissociation of NH_3 (or

……

causes the position of equilibrium of (1) lies to the left). **[1]**

……

The concentration of OH^- is too low for the ppt to form or less ppt formed. **[1]**

……[2]

[Total : 14]

4 Planning

Determination of the hardness of water in a sample.

Hard water is water that has high mineral content and is formed when water percolates through deposits of limestone, chalk and gypsum, which are largely made of calcium carbonates, bicarbonates and sulfates. The hardness of water is measured in terms of the molar concentration of Ca^{2+} in mol dm^{-3}.

In a particular sample of water, the hardness is caused by the presence of calcium chloride. The amount of Ca^{2+}, and hence the concentration of Ca^{2+}, can be determined by precipitation with an excess of oxalic acid.

$$Ca^{2+}(aq) + C_2O_4^{2-}(aq) \rightleftharpoons CaC_2O_4(s)$$

You are to design an experiment to determine the hardness of water in a sample.

You are provided with

- sample of water with estimated hardness of 0.02 mol dm^{-3}
- 0.1 mol dm^{-3} of oxalic acid $H_2C_2O_4$
- electronic balance
- common laboratory apparatus

(a) Given the K_{sp} of calcium oxalate is 2.7×10^{-9} mol^2 dm^{-6} , predict what will be observed when 25.0 cm^3 of the water sample is mixed with equal volume of the 0.1 mol dm^{-3} of oxalic acid solution.

$[Ca^{2+}] = ½(0.02) = 0.01$ mol dm^{-3}
$[C_2O_4^{2-}] = ½(0.1) = 0.05$ mol dm^{-3}
ionic product, IP = $[Ca^{2+}][C_2O_4^{2-}]$
$= (0.01)(0.05)$
$= 5.0 \times 10^{-4}$ mol^2 dm^{-6} [1]

Since IP > K_{sp}, calcium oxalate will be precipitated. [1] (Can award this mark based on correct deduction of IP against Ksp even if IP above is calculated wrongly)

[2]

(b) Your plan should include a step-by-step description of the method, including the

- sequence of steps to ensure that the maximum amount of precipitate is recovered,
- the use of appropriate apparatus,
- the recordings using the letters A, B, C etc to represent the measurement taken and present it with an appropriate table format,
- the processing of the results to determine the molar concentration of Ca^{2+} in the water sample.

[A_r: C, 12.0; Ca, 40.1; H, 1.0; O, 16.0]

Forming of precipitate

1. *Pipette out 25.0 cm^3 of the sample water with a 25.0 cm^3 pipette into a dry and clean 250 cm^3 beaker*
2. *Using a burette, transfer 25.0 cm^3 of 0.1 mol dm^{-3} of oxalic acid into the same beaker (as long as oxalic acid is in excess)*
3. *Stir the mixture thoroughly with a glass rod and leave it to stand for a few minutes for equilibrium to be reached*

Recovering of precipitate

4. *Filter the solution into a 250 cm^3 conical flask and collect the residue precipitate into a pre-weighed filter paper.*
5. *Rinse the beaker and glass rod with small volume of deionised water and transfer the washings and continue to filter.*
6. *Wash the precipitate with limited cold deionised water to get rid of aq ions adsorbed on the surface of precipitate.*
7. *Drain off excess water by pressing the solid between filter papers.*
8. *Dry the precipitate in oven at 80 - 100 ^oC $\pm$ 10%.*
9. *Cool and weigh the dried precipitate*
10. *Repeat the heat cool weigh process until mass is constant to $\pm$0.01g*

Mass of filter paper	*/ g*	*A*
Mass of filter paper and residue after first heating	*/ g*	*B*
Mass of filter paper and residue after second heating	*/ g*	*C*
Mass of filter paper and residue after third heating	*/ g*	*C*
Mass of residue	*/g*	*C – A = E*

Amount of $CaC_2O_4 = \dfrac{E}{40.1+2(12.0)+4(16.0)} = F \text{ mol}$

Ca^{2+} (aq) + $C_2O_4^{2-}$ (aq) $\rightleftharpoons$ CaC_2O_4 (s)

Amt of Ca^{2+} to form CaC_2O_4 = F mol

$[Ca^{2+}]$ in mol $dm^{-3} = \dfrac{F}{\left(\frac{25.0}{1000}\right)} = G \text{ mol dm}^{-3}$

Marks	Requirement	Key marking Points
L-[1]	**Logical flow** of plan	• **Pipetting out water sample into beaker followed by adding fixed solution of oxalic acid into beaker** • **Filtering out precipitate** • **Drying with filter paper and oven or IR lamp (Buchner funnel accepted)** ***Award mark for including all 3 points*.**
A- [1]	Appropriate **apparatus** and their capacities	• **100 cm^3 beaker** • **250 cm^3 beaker** • **250 cm^3 conical flask** • **25.0 cm^3 pipette**
R-[1]	Essential experimental details to ensure **reliable results**	• **Stir mixture with glass rod and leave to stand for a few minutes** • **Repeat heat cool weigh process until mass is constant at $\pm$ 0.01g**
P-[1]	Appropriate volumes with **correct precision**	• **25.0 cm^3 of water sample** • **25.0 cm^3 of oxalic acid**
D-[1]	Appropriate table for tabulation of **data**	• **Correct headers and units** • **Letter**
M-[1]	**Manipulation** of data	• **Correct calculation for mass of residue** • **Correct calculation for the conc of Ca^{2+} in water**

[6]

[Total: 8]