NATIONAL JUNIOR COLLEGE
SH2 Year-End Practical Examination
Higher 2

CANDIDATE NAME	

SUBJECT CLASS		REGISTRATION NUMBER	

CHEMISTRY **9729/04**
Paper 4 Practical **14 August 2018**
Candidates answer on the Question paper **2 hours 30 minutes**
Additional Materials: As listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your identification number and name.
Give details of the practical shift and laboratory where appropriate, in the boxes provided.
Write in 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 18 and 19.

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	/ 14
2	/ 6
3	/ 13
4	/ 9
5	/10
Presentation	/3
Total	/ 55

This document consists of **19** printed pages including this cover page.

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

1 Determination of the average relative formula mass of a mixture of two copper salts

In this experiment, you will determine the average relative formula mass of a mixture of two copper salts by titration.

A solution of the copper salts mixture reacts with excess acidified potassium iodide, producing iodine.

$$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$$

This iodine is then titrated with aqueous sodium thiosulfate, using starch indicator.

FA 1 is an aqueous solution of the copper salt prepared by dissolving 26.0 g of the salt mixture to make 1.00 dm^3 of solution.
FA 2 is dilute sulfuric acid, H_2SO_4.
FA 3 is aqueous potassium iodide, KI.
FA 4 is 1.50 mol dm^{-3} sodium thiosulfate, $Na_2S_2O_3$.
starch indicator

(a) Preparation of diluted FA 4

1. Pipette 25.0 cm^3 of **FA 4** into the 250 cm^3 graduated flask.
2. Make up the contents of the flask to the 250 cm^3 mark with deionised water.
3. Stopper the flask and mix the contents thoroughly to ensure a homogeneous solution.
   This prepared solution is **diluted FA 4**.

Titration

1. Fill the burette with **diluted FA 4**.
2. Pipette 25.0 cm^3 of **FA 1** into a conical flask.
3. Use the measuring cylinder to add approximately 10.0 cm^3 of **FA 2** to the same conical flask.
4. Use the measuring cylinder to add approximately 20.0 cm^3 of **FA 3** to the mixture in the conical flask. The mixture will appear brown, due to iodine produced in the reaction.
5. Begin your rough titration by adding **diluted FA 4** from the burette until the intensity of the brown colour decreases.
6. Add 10 drops of starch indicator. The mixture will become darker.
7. Continue titrating until the dark colour is discharged. The mixture should appear off-white. This is the end-point.
8. Add **one** drop of starch indicator to check that no traces of dark colour are produced.
9. If the mixture stays off-white, the titration is completed. If some dark colour is produced, because iodine is still present, continue the titration until mixture appears off-white.
10. Record your burette readings and the rough titre in the space below.
11. Carry out as many accurate titrations as you think necessary to obtain consistent results.

12. Make sure any recorded results show the precision of your practical work.
13. Record in a suitable form below all of your burette readings and the volume of **diluted FA 4** added in each accurate titration.

[7]

I	
II	
III	
IV	
V	
VI	
VII	

From your accurate titration results, obtain a suitable value for the volume of **diluted FA 4** to be used in your calculations.

Show clearly how you obtained this value.

The iodine produced required .... cm^3 of **diluted FA 4**.
[1]

(b) 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 sodium thiosulfate, $Na_2S_2O_3$, in the volume of **diluted FA 4** obtained in **(a)**.

moles of $Na_2S_2O_3$ = ... mol
[1]

(ii) Balance the ionic equation for the reaction of iodine with sodium thiosulfate. State symbols are not required.

…..... I_2 + ... $S_2O_3^{2-}$ $\rightarrow$ .... $S_4O_6^{2-}$ + ……... I^-

Hence calculate the number of moles of iodine that reacted with the number of moles of $Na_2S_2O_3$ calculated in **(i)**.

moles of I_2 = ... mol
[1]

(iii) Using your answer to **(ii)**, calculate the number of moles of copper(II) ions in 25.0 cm^3 of **FA 1**.

moles of Cu^{2+} ions = ... mol
[1]

(iv) Using your answer to **(iii)** and the information on page 2, calculate the average relative formula mass of the copper salts in **FA 1**.

*Average M*r of copper salts = ...
[1]

(v) Write the full electronic configuration of $_{29}Cu$ in CuI.

…………………………………………………………………………………..…………[1]

(vi) Hence, explain why solid CuI appears white in colour.

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[1]

[Total: 14]

2 Qualitative analysis

In this question, you will deduce the two anions present in **FA 1.** Perform the tests described in **Table 2** and record your observations in the table. Test and identify any gases evolved.

If any solution is warmed, a boiling tube MUST be used.

Table 2

	Test	Observations
(a)	To a 1 cm depth of **FA 1** in a test-tube, add aqueous silver nitrate.	
(b)	To a 0.5 cm depth of **FA 1** in a boiling tube, add aqueous sodium hydroxide and add one piece of aluminium foil and warm.	
(c)	To a 1 cm depth of **FA 1** in a test-tube, add aqueous barium chloride followed by nitric acid.	
(d)	To a 1 cm depth of **FA 1** in a test-tube, add an equal volume of sulfuric acid followed by $KMnO_4$.	

[3]

(e) From your observations, state the anions present in **FA 1**. Explain your answers.

First anion: ………………………… Second anion:…………………………

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

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

[3]

[Total: 6]

3 Investigation of thermal decomposition of sodium hydrogencarbonate

Sodium hydrogencarbonate, $NaHCO_3$, is used as baking soda in cooking. Baking soda may also contain small amounts of other chemicals.

When baking soda is heated, carbon dioxide is produced. In this experiment, you will investigate the reaction taking place when the sodium hydrogencarbonate in baking soda is thermally decomposed.

FA 5 is baking soda (impure $NaHCO_3$).

(a) Method

Record all your readings in the space below.

1. Weigh the crucible with its lid.
2. Transfer all the **FA 5** from the container into the crucible.
3. Weigh the crucible, lid and **FA 5**.
4. Calculate and record the mass of **FA 5** used.
5. Place the crucible and contents on a pipe-clay triangle.
6. Heat gently, **with the lid off**, for approximately one minute.
7. Heat strongly, **with the lid off**, for a further three minutes.
8. Replace the lid and leave the crucible to cool for about ten minutes.

While the crucible is cooling, you should work on other questions.

9. When it has cooled down, weigh the crucible with its lid and contents.
10. Heat strongly, **with the lid off**, for a further two minutes.
11. Replace the lid and leave the crucible to cool for ten minutes.
12. When it has cooled down, weigh the crucible with its lid and contents.
13. Calculate and record the mass of residue obtained.
14. This residue is **FA 6**. Keep this for use in **3(d)**.

Results

I	
II	
III	
IV	

[4]

(b) **Calculations**

(i) Given that the percentage purity by mass of **FA 5** is 95.8%, calculate the mass of sodium hydrogencarbonate in the sample of **FA 5** that you weighed out.

mass of $NaHCO_3$ in **FA 5** weighed out = ... g

(ii) Calculate the mass of impurity present in your sample of **FA 5**.

mass of impurity = ... g
[1]

(iii) The impurity in **FA 5** does not decompose when it is heated.

This means that the residue, **FA 6**, contains the mass of impurity calculated in **(ii)** together with the solid decomposition product of sodium hydrogencarbonate.

Calculate the mass of the solid decomposition product.

mass of solid decomposition product = ... g
[1]

(c) Why was the lid put on while the crucible and its contents were cooled?

....

....
[1]

(d) **(i)** Ah Beng carried out the experiment by heating 84.0 g of pure $NaHCO_3$ to constant mass, he obtained 53.0 g of the solid decomposition product.

Ah Hock then suggested the following equation for the thermal decomposition of sodium hydrogencarbonate.

$$NaHCO_3(s) \rightarrow NaOH(s) + CO_2(g)$$

Explain why Ah Hock's suggestion is **incorrect**. Show working in order to explain your answer.

[A_r: C; 12.0; Na; 23.0; H, 1.0; O: 16.0]

....

.... [1]

(ii) Add 1 cm depth of sulfuric acid into a test-tube.
Add some **FA 6** from the crucible to the acid in the test-tube.
Record all your observations.
Use your observations to identify the anion present in **FA 6**.

....

....

.... [2]

(iii) State the assumption you have made in **(ii)**.

....

.... [1]

(iv) Steam is one of **three** products obtained when sodium hydrogencarbonate is thermally decomposed.

Use your answer in **(ii)** to complete and balance the equation for the thermal decomposition of sodium hydrogencarbonate. Include state symbols.

........$NaHCO_3$(   ) $\rightarrow$ ....H_2O(   ) + ...CO_2(   ) + ...

[1]

(v) State whether the balanced equation in **(iv)** agrees with Ah Beng's results.

Show working in order to explain your answer.

....

....

[1]

[Total: 13]

4 Determination of the enthalpy change of a reaction, ΔH_r

FA 7 is 1.00 mol dm^{-3} sodium hydrogen carbonate, $NaHCO_3$
FA 8 is 2.00 mol dm^{-3} sodium hydroxide, NaOH
FA 9 is 2.00 mol dm^{-3} sulfuric acid, H_2SO_4

An acid-base neutralisation reaction involves reacting the two solutions, to produce water molecules. The equation for this neutralisation reaction is given below.

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

You will follow the instructions to perform two experiments, **Experiment A** and **Experiment B**. Record your results in Tables 4.1 and 4.2.

<u>Experiment A</u>
Reaction between **FA 7**, $NaHCO_3$, and **FA 8**, NaOH.

Reaction 1 $NaHCO_3(aq) + NaOH(aq) \rightarrow Na_2CO_3(aq) + H_2O(l)$ $\Delta H_{reaction1}$

The molar enthalpy change for **reaction 1**, $\Delta H_{reaction1}$, is the enthalpy change when 1.00 mol of $NaHCO_3$ reacts completely with NaOH.

1 Using a measuring cylinder, transfer 30.0 cm^3 of **FA 7** into a Styrofoam cup. Place this cup inside a second Styrofoam cup, which is placed in a 250 cm^3 glass beaker. Place the lid on the cup.

2 Stir and measure the temperature of this **FA 7**, $T_{\mathbf{FA7}}$.

3 Using another measuring cylinder, measure 20.0 cm^3 of **FA 8.**

4 Stir and measure the temperature of this **FA 8**, $T_{\mathbf{FA8}}$.

5 Add **FA 8** from the measuring cylinder to the **FA 7** in the Styrofoam cup. Immediately replace the lid.

6 Using the thermometer, stir the mixture continuously until a maximum temperature is reached. Read and record this temperature T_{max}.

7 Calculate the weighted average initial temperature, $T_{average}$, of **FA 7** and **FA 8** using the formula given below:

$$T_{average} = \frac{(V_{FA7} \times T_{FA7}) + (V_{FA8} \times T_{FA8})}{(V_{FA7} + V_{FA8})}$$

	Experiment A
$T_{\mathbf{FA7}}$ /°C	
$T_{\mathbf{FA8}}$ /°C	
$T_{average}$ /°C	
T_{max} /°C	
ΔT_{max} /°C	

Table 4.1

Experiment B

Reaction between **FA 7**, $NaHCO_3$, and **FA 9,** H_2SO_4.

Reaction 2 $NaHCO_3(aq) + ½H_2SO_4(aq) \rightarrow ½Na_2SO_4(aq) + H_2O(l) + CO_2(g)$ $\Delta H_{reaction2}$

The molar enthalpy change for **reaction 2**, $\Delta H_{reaction\ 2}$, is the enthalpy change when 1.00 mol of $NaHCO_3$ reacts completely with H_2SO_4.

1 Using a measuring cylinder, transfer 30.0 cm^3 of **FA 7** into a Styrofoam cup. Place this cup inside a second Styrofoam cup, which is placed in a 250 cm^3 glass beaker. Place the lid on the cup.

2 Stir and measure the temperature of this **FA 7**, T_{FA7}.

3 Using another measuring cylinder, measure 20.0 cm^3 of **FA 9.**

4 Stir and measure the temperature of this **FA 9**, T_{FA9}.

5 Add **slowly**, the **FA 9** from the measuring cylinder to the **FA 7** in the Styrofoam cup. Immediately replace the lid.

6 Using the thermometer, stir the mixture continuously until a maximum/minimum temperature is reached. Read and record this temperature T_{max}.

7 Calculate the weighted average initial temperature, $T_{average}$, of **FA 7** and **FA 9** using the formula given below:

$$T_{average} = \frac{(V_{FA7} \times T_{FA7}) + (V_{FA9} \times T_{FA9})}{(V_{FA7} + V_{FA9})}$$

	Experiment B
T_{FA7} /°C	
T_{FA9} /°C	
$T_{average}$ /°C	
T_{max} /°C	
ΔT_{max} /°C	

Table 4.2

[2]

(a) For the purpose of calculations, you should assume that the mixture has a density of 1.00 g cm^{-3} and specific heat capacity, c, of 4.18 J g^{-1} K^{-1}.

(i) Use your results from **Table 4.1** to calculate a value for the molar enthalpy change for **reaction 1**, $\Delta H_{reaction1}$.

$\Delta H_{reaction1}$ = ...

[2]

(ii) Use your results from **Table 4.2** to calculate a value for the molar enthalpy change for **reaction 2**, $\Delta H_{reaction2}$.

$\Delta H_{reaction2}$ = ...

[2]

(b) Ionic equations for neutralisation, **reaction 1**, and **reaction 2** are shown below.

$H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$	$\Delta H_{neu} = -57.1$ kJ mol^{-1}
$HCO_3^-(aq) + OH^-(aq) \rightarrow CO_3^{2-}(aq) + H_2O(l)$	$\Delta H_{reaction1}$
$HCO_3^-(aq) + H^+(aq) \rightarrow H_2O(l) + CO_2(g)$	$\Delta H_{reaction2}$

Carbon dioxide reacts with solutions of carbonate ions according to the following equation.

reaction 3 $CO_2(g) + CO_3^{2-}(aq) + H_2O(l) \longrightarrow 2HCO_3^-(aq)$ $\Delta H_{reaction3}$

Using your calculated answers in **(a),** together with the given value of enthalpy change of neutralisation, ΔH_{neu}, construct an energy cycle to determine a value for the enthalpy change for this reaction, $\Delta H_{reaction3}$.

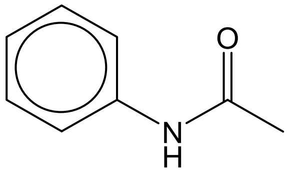
$\Delta H_{reaction3}$ = ……………………

[3]

[Total: 9]

5 **Planning**

The structure of *N*-phenylethanamide is shown below:



N-phenylethanamide, $C_6H_5NHCOCH_3$

The preparation of *N*-phenylethanamide from phenylamine is termed acylation. Ethanoic anhydride, $(CH_3CO)_2O$ is commonly used as an acylating agent as its low reactivity relative to ethanoyl chloride allows the reaction rate to be more easily controlled.

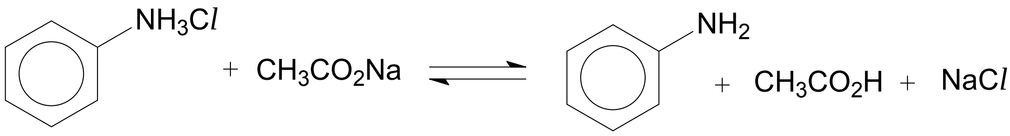
Phenylamine is most conveniently used in the form of the salt phenylammonium chloride, $C_6H_5NH_3Cl$.

The reaction is performed in **two** stages:

Stage **1:**

Phenylamine can be prepared from phenylammonium chloride and sodium ethanoate in an aqueous medium under room temperature.

The reaction is as shown below:



phenylammonium chloride phenylamine

The reaction mixture needs to be continuously stirred for 3 minutes.

Stage **2:**

Phenylamine then reacts with ethanoic anhydride to form solid *N*-phenylethanamide together with ethanoic acid. The addition of ethanoic anhydride to the reaction mixture may be violent.

This mixture is heated under reflux for about 15 minutes, before the crude solid product is removed by filtration and purified by recrystallisation from hot water. The melting point of *N*-phenylethanamide is 114 ^{0}C.

(a) **(i)** State the type of reaction taking place in stage **1**.

.... [1]

(ii) Write an equation for the reaction of phenylamine with ethanoic anhydride in stage **2.**

.... [1]

(b) The above reaction between phenylamine and ethanoic anhydride in stage **2** gives an 80% yield.

Assuming phenylammonium chloride is completely converted to phenylamine in stage **1**, determine the mass of phenylammonium chloride required to prepare 2 g of *N*-phenylethanamide.
(A_r: C: 12.0, H: 1.0, N: 14.0, O: 16.0, C*l*: 35.5)

[2]

(c) Write a full description of the procedure to carry out stages **1** and **2**.
You do not need to describe the recrystallization process to obtain a pure sample of N-phenylethanamide *in stage **2**.*

You may assume that you are provided with :

- 30 cm^3 of water for use as solvent
- 6.0 g of hydrated sodium ethanoate
- 2.0 cm^3 of ethanoic anhydride
- Apparatus normally found in a school or college laboratory

Your plan should include details of:

(i) appropriate quantities of reactants
(ii) appropriate choice of apparatus
(iii) drawing of reflux set-up

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.... [5]

(d) Suggest a method to check the purity of *N*-phenylethanamide obtained.

....
[1]

[Total: 10]

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

anions	***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 by 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 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 potassium manganite(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