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DUNMAN HIGH SCHOOL
Preliminary Examinations 2019
Year 6

H2 CHEMISTRY

Paper 4 Practical

9729/04

27 August 2019
2 hour 30 minutes

INSTRUCTIONS TO CANDIDATES

- 1 Write your **name**, **index number** and **class** on this cover page.
- 2 Give details of the practical shift and laboratory where appropriate, in the boxes provided.
- 3 Write in dark blue or black pen.
- 4 You may use an HB pencil for any diagrams or graphs.
- 5 Do not use staples, paper clips, glue or correction fluid.
- 6 Protective eye goggles and gloves must be worn at ALL TIMES.

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.

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

Shift
Laboratory

For Examiner's Use	
Question No.	Marks
1	17
2	10
3	14
4	14
Total	55

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

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

1 Determination of acid concentration and enthalpy change of neutralisation using calorimetry

When an acid is added into an alkali, an exothermic reaction takes place and the temperature of the mixture increases. Maximum heat is given out when stoichiometric amounts of H^+ and OH^- are added together.

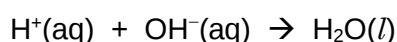
FA 1 is an aqueous solution prepared by mixing *equal volumes* of $y \text{ mol dm}^{-3}$ hydrochloric acid, HCl , and $y \text{ mol dm}^{-3}$ sulfuric acid, H_2SO_4

FA 2 is 2.00 mol dm^{-3} sodium hydroxide, NaOH

In this question, you are to follow the neutralisation of known volumes of **FA 2**, NaOH , by measuring the highest temperature obtained as different volumes of **FA 1** are added.

By measuring the maximum temperature rise for different mixtures of the two reagents, you are to determine the following.

- the value of y , concentration of the acids present in **FA 1**
- the enthalpy change of neutralisation, ΔH_{neut} , for the reaction



(a) Method

- Fill the burette with **FA 2**.
- Support the Styrofoam cup in a 250 cm^3 glass beaker.
- Run 20.00 cm^3 **FA 2** from the burette into the Styrofoam cup. Stir and measure the temperature of this **FA 2**.
- Measure 20 cm^3 **FA 1** in a measuring cylinder.
- Tip the **FA 1** in the measuring cylinder into the **FA 2** cup, stir and record the maximum temperature obtained in the reaction.
- Rinse and carefully dry the Styrofoam cup.
- Repeat **steps 1 to 6** three more times, each time using 20.00 cm^3 of **FA 2**. Use 30.0 cm^3 , 40.0 cm^3 and 50.0 cm^3 of **FA 1** respectively in these different experiments.

Carry out **two further experiments**.

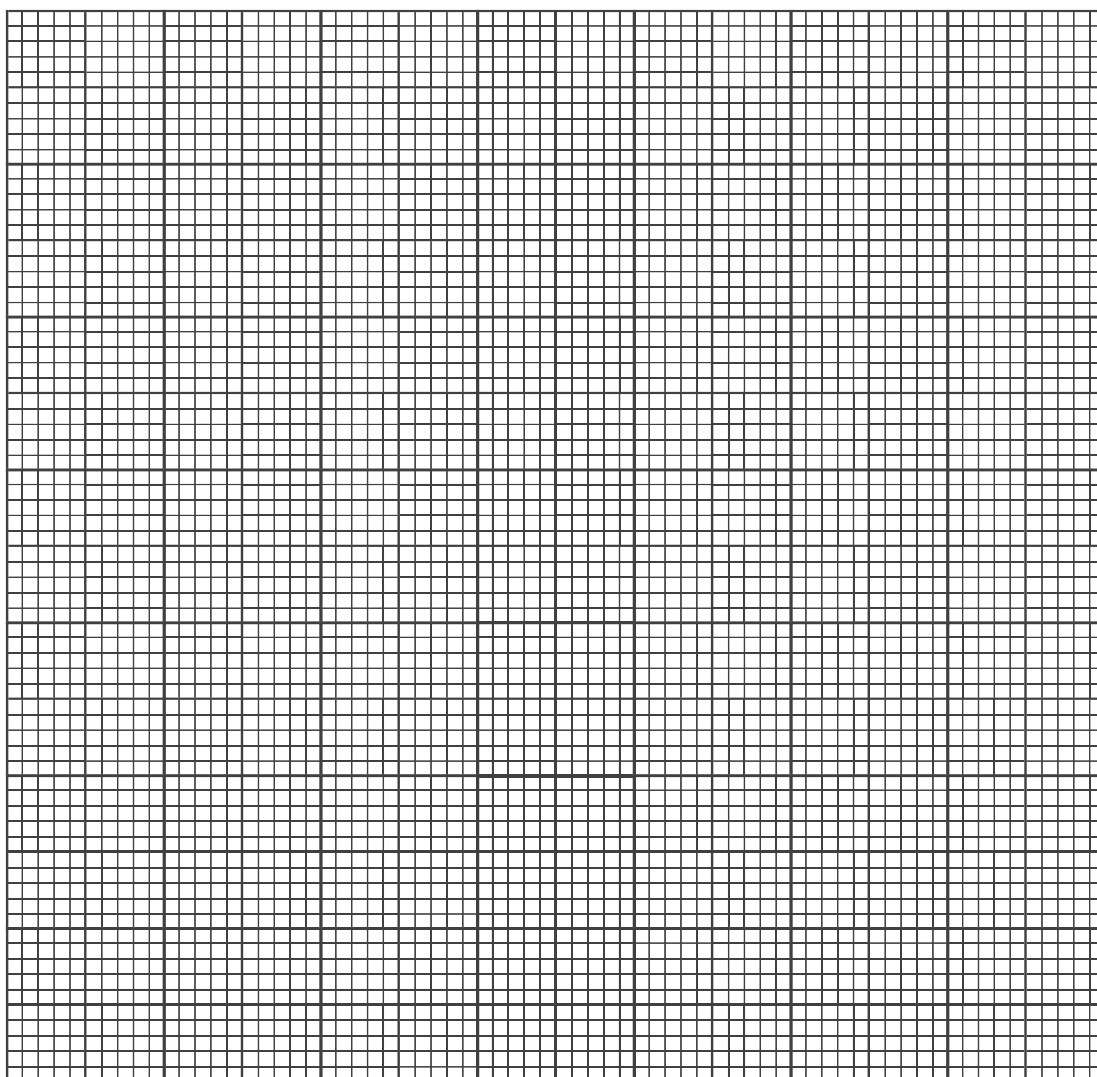
Choose volumes of **FA 1** which will allow you to investigate more precisely the volume of **FA 1** that produces the highest temperature rise when added to 20.00 cm^3 of **FA 2**.

Record your results in an appropriate format in the next page. Record all measurements of volume, temperature and temperature change, ΔT .

(i) Experimental results

[5]

- (ii) Plot ΔT (y -axis) against volume of **FA 1** (x -axis) on the grid below.
Draw a line of best fit through the points where the temperature rise is increasing and another line through the points where the temperature rise is decreasing.



[3]

- (iii) Read from the graph the maximum temperature change, $\Delta T_{\max}$, and the volume, V_{neut} , of **FA 1** needed to obtain this value. Record these values in the spaces provided below.

maximum temperature change, $\Delta T_{\max} = \dots\dots\dots^{\circ}\text{C}$

volume of **FA 1** used at $\Delta T_{\max} = V_{\text{neut}} = \dots\dots\dots \text{cm}^3$
[1]

- (b) Use your results from (a)(iii) to calculate:

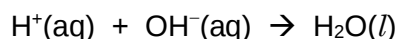
- (i) the concentration, in mol dm^{-3} , of the hydrogen ions in **FA 1**.

concentration of hydrogen ions in **FA 1** = $\dots\dots\dots$
[1]

- (ii) Hence, the value of y .

value of y is $\dots\dots\dots$
[1]

- (iii) the heat change for the reaction and hence the enthalpy change of neutralisation, ΔH_{neut} , for the reaction



[Assume that 4.18 J of energy is needed to raise the temperature of 1 g of the solution by 1 K]

[4]

- (c) A student suggested using a burette rather than a measuring cylinder to measure the volume of **FA 1** to improve the precision in volume measurement. However, he was advised not to do so by his teacher.

Suggest a disadvantage of using a burette and explain how the calculated ΔH_{neut} would be affected if volume of **FA 1** had been added from a burette.

Disadvantage:

.....[1]

Explanation:

.....

.....

.....

.....[1]

[Total:17]

2 Determination of calcium ion concentration using complexometric titration

The calcium content of milk and tap water and the amount of calcium carbonate in various solid samples can be determined using complexometric titrations.

This method uses ethylenediaminetetraacetic acid, EDTA, which forms a complex with calcium ions in a 1:1 ratio. A blue dye called Patton–Reeder indicator is used to identify the end–point. The dye forms a pink complex with calcium ions. As this complex is less stable than the EDTA complex, the dye is displaced by EDTA as the titration proceeds. The solution turns blue at the end–point due to the uncomplexed dye.

FA 3 is a brand of milk.

In **2(a)**, you perform titrations to determine the calcium content of milk.

You are also provided with

FA 2, 2.00 mol dm^{-3} sodium hydroxide, NaOH

FA 4, $0.0170 \text{ mol dm}^{-3}$ EDTA

Patton–Reeder indicator

As EDTA is harmful to the environment, **FA 4** should be disposed in the waste bottle. You should also wear gloves throughout the experiment.

- (a) (i)**
1. Fill the burette with **FA 4**.
 2. Use a pipette to transfer 10.0 cm^3 of **FA 3** into a 250 cm^3 conical flask.
 3. Using appropriate measuring cylinders, add 36.0 cm^3 of deionised water then 8.0 cm^3 of **FA 2** into the conical flask. Swirl and allow the solution to stand for about 2 minutes.
 4. Add half a spatula of Patton–Reeder indicator into the conical flask and swirl the mixture to dissolve the indicator. The mixture is *pink* at this point.
 5. Run **FA 4** from the burette into the conical flask. The end–point is reached when the mixture *loses all trace of purple and turns blue*. As the colour change is gradual, you will find it helpful to compare against the original and / or final colour of another sample.
 6. At the end of the experiment, contents of the conical flask should be disposed in the waste bottle.
 7. Record your titration results, to an appropriate level of precision, in the space provided on the next page.

Titration results

[3]

- (ii) From your titrations, obtain a suitable volume of **FA 4**, $V_{\text{FA 4}}$, to be used in your calculations. Show clearly how you obtained this volume.

$V_{\text{FA 4}} = \dots\dots\dots \text{cm}^3$
[2]

- (b) (i) Calculate the concentration of calcium ions present in **FA 3** using your answer in (a)(ii).

concentration of calcium ions in **FA 3** = $\dots\dots\dots$
[1]

The nutritional label on the packaging states that this brand of milk contains 200 mg of calcium per 200 cm³ serving.

[1 g = 1000 mg]

- (ii) Use your results from (b)(i) to comment if your titration results supports the claim on the nutritional label.

[A_r: Ca, 40.1]

[3]

- (c) Trace amounts of magnesium ions present in milk affects the accuracy of this experiment as magnesium ions also readily form a complex with EDTA.

Explain how step 3 of the procedure prevents this error.

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

[Total: 10]

3 Investigation of some inorganic reactions

FA 5 is an aqueous solution containing two cations.

Carry out the following tests described in Table 3.1 and carefully record your observations.

Unless otherwise stated, the volumes given below are approximate and should be estimated rather than measured. Test and identify any gases evolved. If there are no observable change, write **no observable change**.

Table 3.1

	tests	observations
(a)	(i) Add 1 cm depth of FA 5 to a test-tube. Add an equal volume of aqueous sodium nitrite.	
	(ii) Add 2 cm depth of FA 5 to a test-tube. Add 2 pieces of zinc into the test-tube. Warm the test-tube gently. Leave to stand until no further change is seen.	
	While waiting, continue with the next tests	
	(iii) Add 1 cm depth of FA 5 to a test-tube. Add FA 2 slowly, with shaking, until no further change is seen. Filter the mixture. To 1 cm depth of the filtrate, add nitric acid dropwise until no further change is seen.	
	(iv) Add 1 cm depth of FA 5 to a test-tube. Add aqueous ammonia slowly with shaking, until no further change is seen. Filter the mixture.	

(v)	To 1 cm depth of the filtrate from (iv), add 1 cm depth of aqueous EDTA⁴⁻ from the small vial with shaking. <i>The mixture at the end of this test should be disposed in the waste bottle.</i>	
(vi)	Add 4 cm depth of FA 5 to a test-tube. Add 2 cm depth of aqueous sodium carbonate. The total depth of the mixture should not exceed half the test-tube. Shake well. Leave to stand for a few minutes. Filter the resultant mixture.	
(vii)	Transfer the residue from (vi) to a boiling tube. Heat gently then strongly until no further change is seen.	

[7]

(b) Consider your observations in Table 3.1.

(i) State the identity of the two cations present in **FA 5**.

..... and

[1]

The wavelengths and corresponding colours of visible light is shown in Figure 3.1.

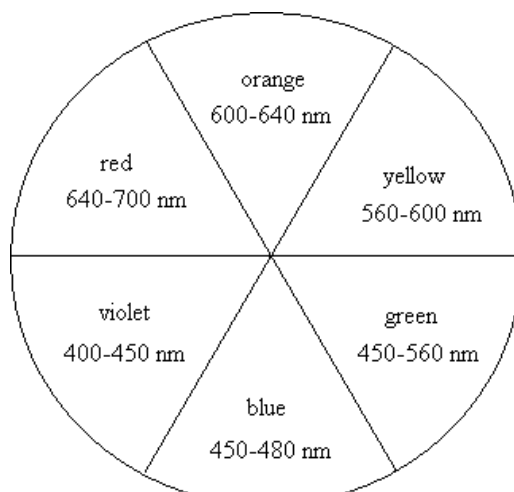


Fig. 3.1

- (ii) In terms of the magnitude of d-orbital splitting, account for the colour change observed in (a)(i).

.....

.....

.....

.....

.....

..... [2]

In (a)(v), a ligand exchange occurs with hexadentate EDTA^{4-} .

- (iii) Write a balanced equation for the ligand exchange reaction in (a)(v).

..... [1]

- (iv) Each donor atom on EDTA^{4-} binds to the metal centre with similar strength as an ammonia molecule and a water molecule.

Using this information and your answer to (b)(iii), estimate the enthalpy change for the reaction in (a)(v) and suggest why it occurs spontaneously.

.....

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..... [2]

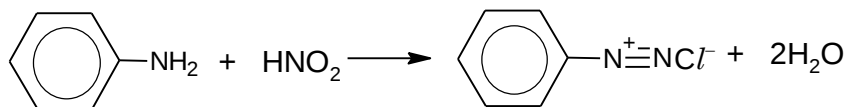
- (v) Write a balanced equation for the reaction occurring in (a)(vii).

..... [1]

[total: 14]

4 Planning

When an aromatic amine is treated with nitrous acid, a reaction occurs in which *diazonium salt* is formed. This process is known as **diazotisation**. The equation below shows the reaction between phenylamine and nitrous acid to form benzenediazonium chloride, $\text{C}_6\text{H}_5\text{N}_2^+\text{Cl}^-$.



Benzenediazonium chloride, $\text{C}_6\text{H}_5\text{N}_2^+\text{Cl}^-$, is not stable at temperature above 5°C .

Nitrous acid is a highly toxic gas. Therefore, it is generally prepared during the reaction itself by reacting NaNO_2 with a mineral acid.

A student followed the steps below to prepare benzenediazonium chloride.

1. 3.25 cm^3 of phenylamine was placed in a 500 cm^3 volumetric flask.
2. A mixture of 30 cm^3 of concentrated hydrochloric acid and 30 cm^3 of water was added into the flask containing phenylamine to dissolve it.
3. The solution mixture was stirred and cooled to 1°C .
4. Solid NaNO_2 was dissolved in 30 cm^3 of water, then *slowly and carefully* added to the solution mixture, with stirring.
5. The resultant solution was made up to 500 cm^3 with water, mixed well and kept cool below 5°C . This resultant benzenediazonium chloride solution prepared is labelled solution **B**.

(a) Suggest why NaNO_2 solution was added *slowly and carefully* in step 4.

.....
[1]

When the temperature is above 5 °C, benzenediazonium chloride hydrolyses to give phenol, nitrogen gas and hydrochloric acid.



The temperature of a portion of 25.0 cm³ of solution **B** was raised to room temperature at constant pressure.

- (b) (i) Calculate the theoretical maximum volume of N₂ produced when 25.0 cm³ of solution **B** is hydrolysed at room temperature and pressure.

[M_r of phenylamine = 93.0; density of phenylamine = 1.02 g cm⁻³; molar volume of gas at room temperature and pressure = 24.0 dm³ mol⁻¹]

[3]

Another 25.0 cm³ portion of solution **B** was transferred to a boiling tube and the hydrolysis of benzenediazonium chloride was carried out at 40 °C.

The progress of the reaction can be monitored by measuring the volume of nitrogen gas produced over time. The volume of gas produced, *V* after time, *t*, is proportional to the concentration of benzenediazonium chloride that has been hydrolysed. The final volume of gas produced, *V*_{final}, is proportional to the original concentration of benzenediazonium chloride.

The order of reaction can be determined from these results.

- (ii) Explain the significance of *V*_{final} – *V*.

.....
[1]

- (iii) Sketch, on Fig 4.1, the graph of $V_{\text{final}} - V$ against time you would expect to obtain if the order of reaction with respect to $[\text{C}_6\text{H}_5\text{N}_2^+\text{Cl}^-]$ is one.



Fig 4.1

[2]

The volume of nitrogen produced was collected using the modified apparatus as shown in Fig. 4.2 below.

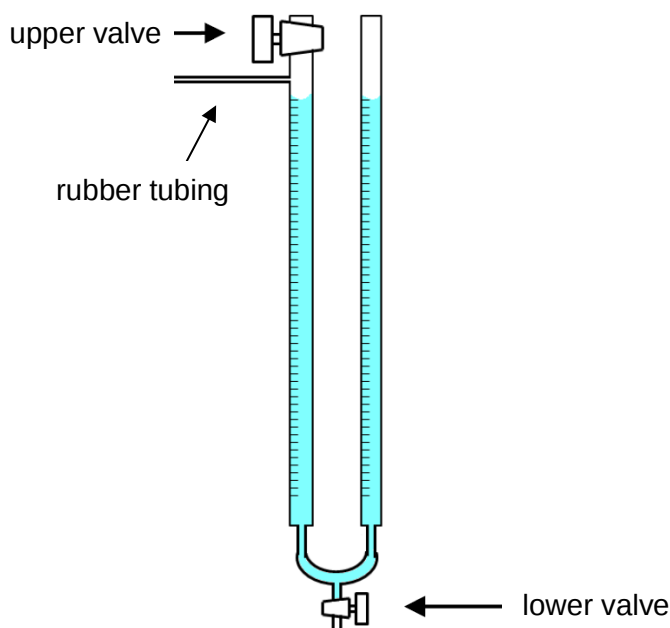


Fig. 4.2

At the start, the lower valve is closed and the upper valve is opened. The two burettes are filled with water and both levelled to 0.00 cm^3 . The upper valve is closed once the hydrolysis of benzenediazonium chloride begins. As gas is collected during the experiment, the water level in both burettes will differ slightly. The lower valve is opened and closed carefully from time to time to ensure that the water levels in the two burettes are the same.

Outline the steps involved in carrying out the experiment. You may omit the step to prepare the burettes above for gas collection before the reaction begins.

Your steps should include

- the apparatus you would use
- the reactants and conditions that you would use
- the measurements you would take.

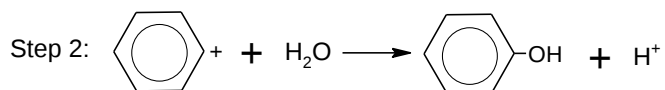
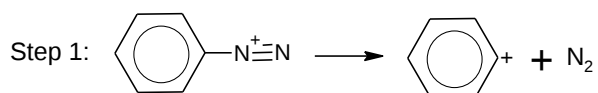
[5]

- (v) Why is there a need to ensure that the water level in both burettes are the same during the experiment?

.....

[1]

- (c) Benzenediazonium chloride hydrolyses in water according to the following steps.



Deduce the role of H₂O and suggest the likely type of reaction occurring.

.....

[1]

[Total:14]