Manipulation, Measurement & Observation

Question Paper 1

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Manipulation, measurement & observation
Booklet	Question Paper 1

Time Allowed: **61 minutes**

Score: **/51**

Percentage: **/100**

Grade Boundaries:

1 A student suggests that the concentration of sulfuric acid can be determined by measuring the temperature of the solution as the acid is added in small amounts to a known volume of sodium hydroxide solution in a plastic cup.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

The student proposes the following hypothesis.

As the acid is added to the alkali the temperature rise will be directly proportional to the volume of acid added until the end-point of the reaction is reached. Upon further addition of acid there will be a reduction in the temperature of the solution in the cup as the acid added is not reacting and is at a lower temperature than the solution in the plastic cup.

The following reagents are provided.

FA 1 is 2.00 mol dm^{-3} sodium hydroxide, NaOH.
FA 2 is **approximately** 0.75 mol dm^{-3} sulfuric acid, H_2SO_4.

(a) Use the equation for the reaction to estimate the volume of **FA 2** that will neutralise 25.0 cm^3 of **FA 1**.

volume of **FA 2** = ... cm^3 [1]

(b) In the experiment you will add **FA 2** from the burette to 25.0 cm^3 of **FA 1** in a plastic cup. You will measure the temperature of the solution after each addition of a certain volume of acid. You will then plot a graph of the temperature rise against the volume of acid added and use this to determine the end-point. You will then be able to calculate the concentration of H_2SO_4 in **FA 2**.

In order to obtain precise information about the end-point of the reaction, you will need to decide:

- the volume of acid to be added each time (do not use a volume which is less than 2.00 cm^3)
- the total volume of acid to be added.

volume of acid to be added each time = ... cm^3

total volume of acid to be added = ... cm^3 [2]

(c) Method

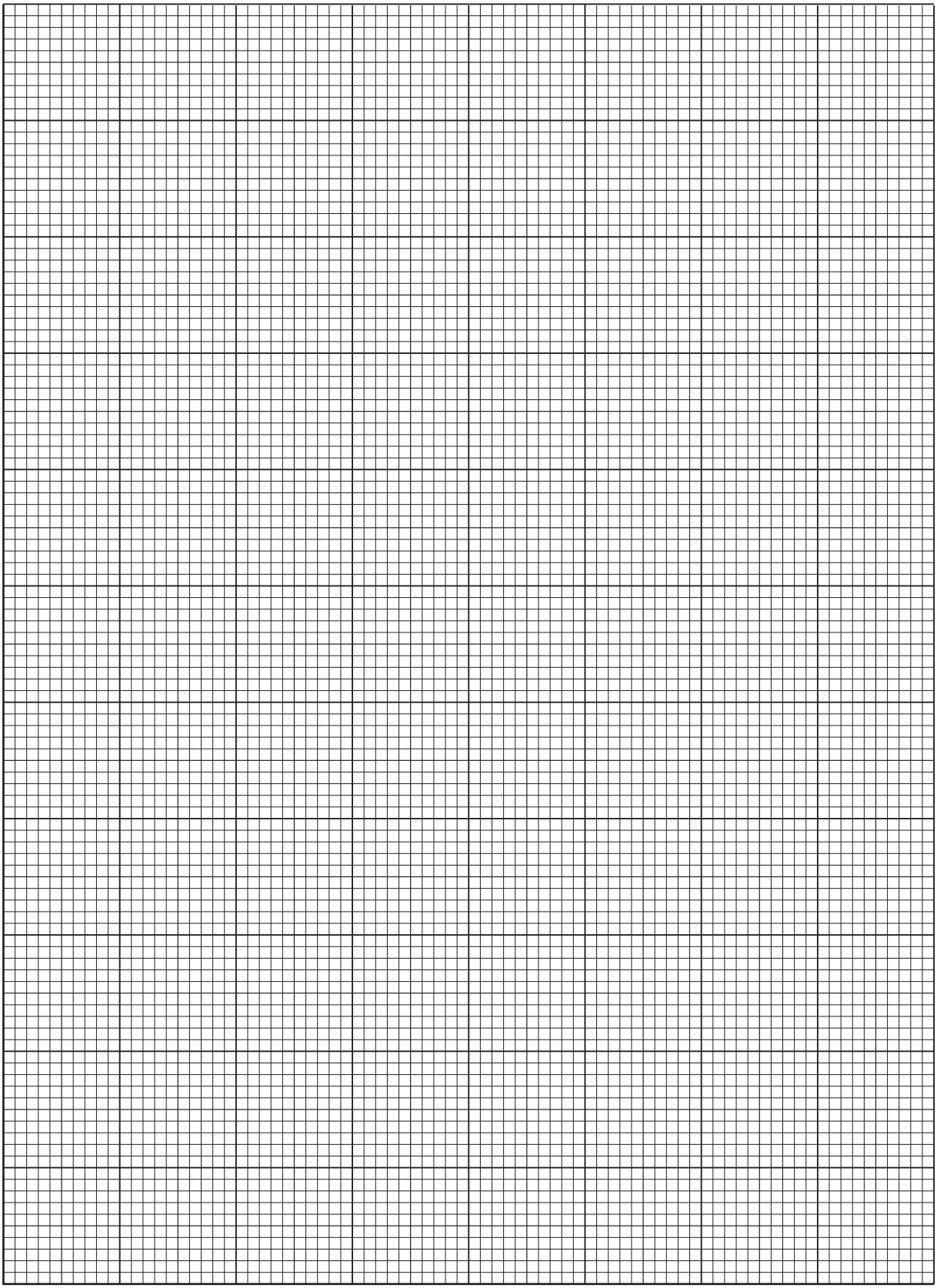
1. Fill the burette with **FA 2**.
2. Support the plastic cup in the 250 cm^3 beaker.
3. Pipette 25.0 cm^3 of **FA 1** into the plastic cup.
4. Measure and record the temperature of **FA 1** in the plastic cup.
5. Add the first volume of **FA 2** from the burette into the plastic cup. Stir the solution and record the highest temperature that is observed.
6. Continue to add each volume of **FA 2** and record the highest temperature observed.

Record in the space below:

- the initial temperature of **FA 1**
- the total volume of **FA 2** added at each stage in the experiment
- the temperature of the solution in the plastic cup after each addition of acid
- the temperature rise, ΔT, where ΔT = highest temperature of the solution after each addition of acid – initial temperature of **FA 1**.

[6]

(d) On the grid below plot the temperature rise, ΔT, (y-axis) against the volume of **FA 2** added (x-axis).



[4]

(e) **(i)** Use your graph to obtain a value for the volume of **FA 2** added at the end-point of the titration.

volume of **FA 2** at the end-point = ... cm^3 [1]

(ii) Use your answer to **(i)** to calculate the concentration of H_2SO_4 in **FA 2**.
Show your working.

concentration of **FA 2** = ... $mol\,dm^{-3}$ [2]

(f) Explain how the results of your experiment support or do not support each part of the hypothesis proposed by the student.

.....

.....

.....

..... [2]

(g) Calculate the % error in the total volume of **FA 2** added from the burette for the volume which is closest to the end-point.

..... % [2]

(h) A student carrying out the same experiment noticed that each subsequent temperature rise became less as the end-point was approached. Give **two** reasons why this was the case.

reason 1 .....

.....

reason 2 .....

..... [2]

(i) Another student put forward the hypothesis that the heat energy produced in the reaction, rather than the temperature rise, is proportional to the volume of acid added.

Calculate the total heat produced by the addition of **FA 2** at the end-point.
Assume that it takes 4.2 J to raise the temperature of 1.0 cm^3 of solution by 1.0 °C.

heat produced = ... J [1]

[Total: 23]

2. **FA 1** is a mixture of barium chloride dihydrate, $BaCl_2.2H_2O$, and one other barium salt.
When barium chloride dihydrate is heated the anhydrous salt is formed.

$$BaCl_2.2H_2O \rightarrow BaCl_2 + 2H_2O$$

You will first measure the mass lost on heating the mixture and so determine the percentage by mass of the barium chloride dihydrate.

You will then identify the anion in the second salt.

(a) Method

Before starting any practical work, read through all the instructions and prepare a table for your results in the space provided.

You have been provided with two samples of FA 1.

1. Weigh a clean dry crucible without a lid and record your reading.
2. Place in the crucible all of the contents of one of the containers of **FA 1**.
3. Reweigh the crucible and record your reading.
4. Support the crucible in the pipe-clay triangle on top of a tripod.
5. Heat the crucible **gently** for about 1 minute and then **strongly** for a further 8 minutes.
6. Allow the crucible to cool.
   While the crucible is cooling you are advised to start Question 2.
7. As soon as the crucible is cool enough to touch, reweigh the crucible and its contents and record your reading.
8. Calculate and record the initial mass of the mixture and the mass of water lost.

I	
II	
III	
IV	

[4]

(b) By performing the following calculations you will determine the percentage by mass of barium chloride dihydrate in the mixture.
You must show your working in each step of your calculations.

(i) Calculate the amount, in mol, of water lost from the sample of **FA 1**.

..... mol

(ii) Calculate the percentage by mass of barium chloride dihydrate, $BaCl_2.2H_2O$, present in **FA 1**.

I	
II	
III	

..... %
[3]

(c) Place approximately half of the second sample of **FA 1** into a test-tube and add cautiously some dilute hydrochloric acid. Do **not** use the hydrochloric acid labelled **FA 3**.

Test any gases that are given off and record all your observations in the space below. Identify the anion present in the second salt.

The anion in the second salt is ..... . [3]

(d) In determining the percentage by mass of barium chloride dihydrate in **FA 1**, it is necessary to assume that the second salt has a particular property.

State what this property is and explain why this is essential for the method to be valid.

.....

.....

.....[2]

[Total: 12]

3. A student was given a sample containing a mixture of ammonium chloride and one other salt. The student was told to determine the percentage by mass of ammonium chloride in the sample. To do this, the student carried out the following steps.

step 1 1.40 g of the mixture was dissolved in exactly 250.0 cm^3 of 0.200 mol dm^{-3} sodium hydroxide, NaOH.

step 2 This solution was transferred to a large conical flask and heated. The sodium hydroxide reacted with the ammonium chloride as shown in the equation.

$$NaOH(aq) + NH_4Cl(aq) \rightarrow NH_3(g) + NaCl(aq) + H_2O(l)$$

step 3 The student tested for the ammonia gas given off and when no more gas was being formed, the solution was allowed to cool to room temperature and was labelled **FA 2**.

You are provided with some of this solution, **FA 2**. By titration with hydrochloric acid, HCl, you are to determine the amount of sodium hydroxide left in the solution. This will enable a percentage by mass of the ammonium chloride in the mixture to be determined, assuming that the student's method is valid.

The following reagents are provided.

FA 2, the solution prepared by the student
FA 3, 0.100 mol dm^{-3} hydrochloric acid, HCl
methyl orange indicator

(a) Method

Before starting any practical work, read through all the instructions and prepare a suitable table for your results in the space provided.

1. Fill a burette with the hydrochloric acid, **FA 3**.
2. Use a pipette to transfer 25.0 cm^3 of **FA 2** into a conical flask.
3. Add 5 drops of methyl orange indicator to the conical flask.
4. Titrate the solution in the flask with **FA 3**.
5. Repeat the titration as many times as you feel are necessary in order to obtain consistent results.
6. Record your results in a suitable form in the space below.
7. Clearly indicate the results you will use to calculate the average titre.

I	
II	
III	
IV	
V	
VI	

[6]

(b) From your titration results calculate the average titre.

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

(c) **You must show your working and use appropriate significant figures in the answer for each step of your calculations.**

(i) Calculate the amount, in mol, of hydrochloric acid present in the average titre of **FA 3**.

..... mol

(ii) Calculate the amount, in mol, of sodium hydroxide present in 250.0 cm^3 of **FA 2**.

..... mol

(iii) Calculate the amount, in mol, of ammonium chloride present in the mixture.

..... mol

(iv) Calculate the percentage by mass of ammonium chloride present in the mixture.

I	
II	
III	
IV	
V	

..... %
[5]

(d) In the titration you have carried out, volumes were measured using both a burette and a pipette.
Using one of your accurate titration results, determine whether the percentage error is greater or less for this titre value than it is for the volume measured using the pipette.
You should assume that the 25 cm^3 pipette has an uncertainty of ± 0.06 cm^3.
Show your working.

[2]

(e) A second student claimed that the method used by the first student could be improved so that the value obtained for the percentage by mass was more accurate. In the modified method the analysis was carried out as follows.

step 1 1.40 g of the mixture was dissolved in exactly 250.0 cm^3 of 0.200 mol dm^{-3} sodium hydroxide, NaOH.

step 2 Using a pipette, 25.0 cm^3 of this solution was transferred to a conical flask and heated.

step 3 The student tested for the ammonia gas given off and when no more gas was being formed, the solution was allowed to cool to room temperature.

step 4 The cooled solution was then titrated with 0.100 mol dm^{-3} hydrochloric acid.

step 5 Steps 2 to 4 were repeated until consistent results were obtained.

Discuss whether you agree that this method would give a more accurate value for the percentage by mass of ammonium chloride. Explain how the percentage you calculated in **(c)(iv)** would compare with the value determined using this second method.

.....

.....

.....

.....[2]

[Total: 16]