Manipulation, Measurement & Observation

Question Paper 2

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Manipulation, measurement & observation
Booklet	Question Paper 2

Time Allowed: **59 minutes**

Score: **/49**

Percentage: **/100**

Grade Boundaries:

1 In this experiment you will determine the relative proportions of sodium carbonate and sodium hydrogencarbonate in a mixture. You will first make up a solution from a mixture of the salts and then titrate this solution using hydrochloric acid.

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

$$HCl(aq) + NaHCO_3(aq) \rightarrow NaCl(aq) + H_2O(l) + CO_2(g)$$

The following reagents are provided.

FA 1 is a mixture of anhydrous sodium carbonate, Na_2CO_3, and sodium hydrogencarbonate, $NaHCO_3$.

FA 2 is 0.200 mol dm^{-3} hydrochloric acid, HCl.

methyl orange indicator

(a) Method

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

Preparing the solution

1. Weigh the weighing bottle containing **FA 1**.
2. Tip the contents of the weighing bottle into a 250 cm^3 beaker.
3. Reweigh the weighing bottle.
4. Add approximately 150 cm^3 of distilled water to the beaker and stir until the mixture of salts has dissolved.
5. Transfer the contents carefully into the 250 cm^3 volumetric flask.
6. Rinse the beaker with a little distilled water and add these washings to the volumetric flask.
7. Fill the volumetric flask to the line with distilled water. Stopper the flask and invert several times to ensure thorough mixing.

Record in the space below both weighings and the mass of **FA 1** added.

Titration

8. Fill a burette with the hydrochloric acid, **FA 2**.
9. Use a pipette to transfer 25.00 cm^3 of the solution from the volumetric flask into a conical flask.
10. Add 5 drops of methyl orange indicator to the conical flask.
11. Titrate the solution in the conical flask with **FA 2**.
12. Repeat the titration as many times as you feel are necessary to obtain consistent results.
13. Record your results in a suitable form in the space below.

[8]

(b) From your titration results obtain a volume of **FA 2** to be used in the following calculations. Show clearly how you obtained this value.

25.00 cm^3 of the solution of **FA 1** required …… cm^3 of **FA 2**.

[2]

(c) By performing the following calculations you will determine the mass of sodium hydrogencarbonate present in **FA 1**.

You must show your working.

(i) Calculate the amount, in mol, of hydrochloric acid present in the volume of **FA 2** calculated in **(b)**.

…… mol

(ii) Calculate the amount, in mol, of hydrochloric acid that would have reacted with the total mass of **FA 1**.

…… mol

(iii) Use your answer to **(c)(ii)** and the following expression to calculate the mass of sodium hydrogencarbonate in **FA 1**.

$$2\left(\frac{M - m}{106}\right) + \frac{m}{84} = \text{answer to } \textbf{(c)(ii)}$$

where
M = the mass of **FA 1**
m = the mass of sodium hydrogencarbonate

the mass of sodium hydrogencarbonate in **FA 1** = …… g
[3]

[Total: 13]

2 Another way to analyse a mixture of sodium carbonate and sodium hydrogencarbonate is to measure the temperature change that occurs when a known mass of the mixture is added to acid.

FA 3 is a mixture of anhydrous sodium carbonate, Na_2CO_3, and sodium hydrogencarbonate, $NaHCO_3$. This mixture is **not** the same as **FA 1**.

FA 4 is 2.00 mol dm^{-3} hydrochloric acid, HC*l*.

(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. Support a plastic cup in a 250 cm^3 beaker.
2. Using a 25 cm^3 measuring cylinder, pour 25 cm^3 of **FA 4**, the hydrochloric acid, into the plastic cup.
3. Measure the temperature of the acid in the cup.
4. Weigh the bottle containing **FA 3**.
5. Add the contents of the bottle to the acid in a number of portions to avoid acid spray.
6. Use the thermometer to stir the mixture gently.
7. Measure the temperature that is reached.
8. Reweigh the bottle.

Record all the measurements from your experiment. Include the mass of **FA 3**, *M*, added to the acid and the change in temperature, ΔT, where ΔT = final temperature – initial temperature.

[4]

(b) In the following calculations you will work out the percentage by mass of sodium hydrogencarbonate in **FA 3**.

You must show your working.

(i) Calculate the change in temperature for each gram of **FA 3** added to the acid.

$\frac{\Delta T}{M}$ = ... °C g^{-1}
sign

(ii) A student carried out similar experiments using separate samples of the two salts.

For pure sodium carbonate the change in temperature per gram was +3.38 °C g^{-1}.

For pure sodium hydrogencarbonate the change in temperature per gram was –2.74 °C g^{-1}.

Use these values and your answer to **(b)(i)** to calculate the mass and the percentage by mass of sodium hydrogencarbonate in **FA 3**.

If your answer to **(b)(i)** does **not** lie between +3.38 and –2.74 °C g^{-1} then assume that the answer to **(b)(i)** is +1.36 °C g^{-1}. This is not the correct value.

mass of sodium hydrogencarbonate = ... g

percentage by mass of sodium hydrogencarbonate = ... %
[5]

(c) **(i)** State the uncertainty in the measurement of **each** mass in this experiment.

uncertainty = ± ..... g

(ii) Calculate the percentage error in the mass of **FA 3** that was used.

percentage error = ... %
[1]

(d) The experiment was repeated using the **same** apparatus but this time twice the mass of **FA 3** was added to 50 cm^3 of the hydrochloric acid.

Discuss whether this would determine more accurately the percentage of sodium hydrogencarbonate in **FA 3**.

.....

.....

.....

.....[2]

[Total: 12]

3. **FA 1** is a Group 2 metal chloride dihydrate, $MCl_2.2H_2O$. By measuring the mass loss on forming the anhydrous salt the identity of *M* can be determined.

(a) Method

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

1. Weigh a clean dry crucible without a lid and record your reading.
2. Place in the crucible the entire sample of the salt, **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 more strongly for a further 4 minutes.
6. Allow the crucible to cool.
   While the crucible is cooling you may wish to start another question.
7. As soon as the crucible is cool enough to handle, reweigh the crucible and its contents and record your reading.
8. Calculate and record the mass of the residue and the mass of water lost.

Results

[4]

(b) Use your measurements to identify the Group 2 metal present in **FA 1**, $MCl_2.2H_2O$.
You must show your working.

[3]

(c) Starting with the same mass of **FA 1**, suggest how you could have modified the experiment to determine more accurately the mass of water lost.

.....

.....[1]

[Total: 8]

4. **FA 2** is an anhydrous Group 1 metal chloride. By titrating a solution of **FA 2** with aqueous silver nitrate, the percentage by mass of chloride in the salt can be determined. The equation for the reaction is shown below.

$$Ag^{+}(aq) + Cl^{-}(aq) \rightarrow AgCl(s)$$

The following reagents are provided.

FA 2 is the Group 1 metal chloride
FA 3 is $0.0500\,mol\,dm^{-3}$ silver nitrate
FA 4 is neutral chromate indicator (aqueous potassium chromate)

(a) Method

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

Preparing the solution

1. Weigh the weighing bottle containing the metal chloride, **FA 2**, and record your reading.
2. Tip the contents of the weighing bottle into a $100\,cm^3$ beaker.
3. Reweigh the empty weighing bottle and record your reading.
4. Calculate and record the mass of **FA 2** added to the beaker.
5. Add distilled water to the beaker and stir until the metal chloride has dissolved.
6. Transfer the contents carefully into the $250\,cm^3$ volumetric flask.
7. Rinse the contents of the beaker with a little distilled water and add these washings to the volumetric flask.
8. Fill the volumetric flask to the line with distilled water. Stopper the flask and invert several times to ensure thorough mixing.

Results

Titration

9. Fill a burette with silver nitrate solution, **FA 3**.
10. Use a pipette to transfer 25.00 cm^3 of the metal chloride solution into a conical flask.
11. Add 10 drops of the chromate indicator, **FA 4**, using a dropping pipette.
12. Run the solution from the burette into the conical flask until the precipitate takes on a permanent pink colour.
13. Repeat the titration as many times as you feel are necessary to obtain consistent results.
14. Record your results in a suitable form in the space below.

Results

[7]

(b) From your titration results obtain a volume of **FA 3** to be used in the following calculations. Show clearly how you obtained this value.

25.00 cm^3 of the solution of **FA 2** required …… cm^3 of **FA 3**. [2]

(c) By performing the following calculations you will be able to work out the percentage by mass of chloride ions present in **FA 2**.
You must show your working.

(i) Calculate the amount, in mol, of silver nitrate present in the volume of **FA 3** calculated in **(b)**.

…… mol

(ii) Calculate the amount, in mol, of chloride ions present in your weighed sample of **FA 2**.

…… mol

(iii) Calculate the percentage by mass of chloride ions in **FA 2**.

the percentage by mass of chloride ions in **FA 2** = …… %
[5]

(d) A source of error in this experiment involves the burette readings.

(i) What is the uncertainty of each titre recorded in **(a)**? Explain your answer.

.....

.....[1]

(ii) Assuming that:
- your answer to **(d)(i)** is the error in the value you calculated in **(b)** and
- this is the only error in the experimental procedure,

calculate the minimum value for your percentage by mass of chloride ions in **FA 2**.

The minimum percentage by mass of chloride ions in **FA 2** is …… [1]

[Total: 16]