Manipulation, Measurement & Observation

Question Paper 3

Level	Pre U
Subject	Chemistry
Exam Board	Cambridge International Examinations
Topic	Manipulation, measurement & observation
Booklet	Question Paper 3

Time Allowed: **68 minutes**

Score: **/57**

Percentage: **/100**

Grade Boundaries:

1 The acid catalysed reaction between iodine and propanone proceeds relatively slowly at room temperature.

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + H^+(aq) + I^-(aq)$$

The rate of this reaction can be determined by following the change in the concentration of iodine as the reaction proceeds. At set time intervals, a small volume of the reaction mixture is removed and added to a solution of sodium hydrogen carbonate. This effectively stops the reaction by neutralising the acid catalyst. The concentration of iodine can then be determined by titration using sodium thiosulfate solution.

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

In the following experiment you will carry out this titration to determine the concentration of iodine.

You are provided with a solution labelled **FA 1**. This solution was obtained by removing 25.00 cm^3 of the reaction mixture and adding excess sodium hydrogen carbonate solution. The mixture was then made up to 150.0 cm^3 using distilled water.

FA 2 contains 0.0500 mol dm^{-3} sodium thiosulfate solution, $Na_2S_2O_3(aq)$.

Read all of the following instructions before you start any experimental work and draw up a table to record your results in part **(a)**.

Method

1. Fill a burette with **FA 2**.
2. Pipette 25.00 cm^3 of **FA 1** into a conical flask.
3. Run the solution from the burette into the conical flask until the red/brown colour of the iodine becomes pale yellow.
4. At this point add approximately 10 drops of starch indicator.
5. Continue to add **FA 2** until the blue/black colour completely disappears.
6. Repeat the titration until you have obtained consistent results.

(a) Record your titration results in the space below. Make sure your recorded results show the precision of your practical work.

[5]

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

(c) From the measurements you have made, determine the concentration of the iodine in the reaction mixture at the time when the 25.00 cm^3 sample was removed.
Show your working and give your answer to an appropriate number of significant figures.

.....[5]

(d) In another experiment using different starting concentrations of iodine, propanone and acid, the following values were obtained for the concentration of iodine in the reaction.

time / min	$[I_2(aq)]$ / mol dm^{-3}
0	0.0100
5	0.0096
10	0.0092
15	0.0088

Use the figures shown above to determine the order of the reaction with respect to iodine. Explain your answer.

.....

.....

.....[2]

[Total: 13]

2 As zinc is above copper in the reactivity series, it readily displaces copper from its salts. In this experiment you will determine the enthalpy change for the following displacement reaction.

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

FA 3 is powdered zinc.
FA 4 is 1.00 mol dm^{-3} copper sulfate, $CuSO_4(aq)$.

(a) Method

Before starting any practical work, read all of the following instructions.

1. Support a foamed plastic cup in a 250 cm^3 beaker.
2. Using a 50 cm^3 measuring cylinder, pour 40 cm^3 of the copper sulfate solution, **FA 4**, into the plastic cup.
3. Measure the temperature of the copper sulfate solution.
4. Remove the stopper from the bottle containing **FA 3**.
5. Weigh the bottle.
6. Add the contents of the bottle to the copper sulfate solution in the plastic cup.
7. Use the thermometer to stir the mixture gently.
8. Measure the highest temperature that is reached.
9. Reweigh the unstoppered bottle.

In a suitable format record all the measurements from your experiment, including the **mass of zinc** added and the **change in temperature**.

[4]

(b) Calculate the heat energy given out by the reaction. Assume that the specific heat capacity of the solution is 4.18 J g^{-1} K^{-1} and that the density of the solution is 1.00 g cm^{-3}.

the heat energy given out by the reaction = ... J [1]

(c) In the experiment you have carried out the copper sulfate is in excess. Calculate the enthalpy change, in $kJ\,mol^{-1}$, for the displacement reaction.
[A_r: Zn, 65.4]

enthalpy change = ... $kJ\,mol^{-1}$ [1]

(d) The standard enthalpy change of formation for $Cu^{2+}(aq)$ is $+64.3\,kJ\,mol^{-1}$, while the standard enthalpy change of formation for $Zn^{2+}(aq)$ is $-152.3\,kJ\,mol^{-1}$. Use these values to calculate the standard enthalpy change of reaction for:

$$Zn(s) + CuSO_4(aq) \rightarrow ZnSO_4(aq) + Cu(s)$$

enthalpy change = ... $kJ\,mol^{-1}$ [1]

(e) **(i)** Express the difference between the values calculated in **(c)** and **(d)** as a percentage of the value calculated in **(d)**.

% difference = ...[1]

(ii) The most significant source of error in this experiment is heat loss to the surroundings. Suggest one further source of error.

.....

.....

.....[1]

(iii) Suggest two improvements that would reduce this error.

.....

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.....[2]

[Total: 11]

Before starting question 3, half-fill a 250 cm^3 beaker with water and heat with a Bunsen burner to between 70 and 80 °C. You will use this as a hot water-bath in part (c) of this question. Turn off the Bunsen burner.

3 **(a)** Solutions **FA 5** and **FA 6** each contain a single cation, from those listed in the Qualitative Analysis Notes. These cations are different. By observing the reactions with sodium hydroxide solution and with aqueous ammonia, it is possible to suggest identities for these cations.
Record your observations in an appropriate format in the space below, and hence suggest identities for the cations.

FA 5 contains ..... **FA 6** contains ..... [7]

(b) **(i)** **FA 7** contains a mixture of two anions from those listed in the Qualitative Analysis Notes. **FA 8** contains a single cation from those listed in the Qualitative Analysis Notes. Carry out the following tests and record your observations in the table below.

test	observation
To a 1 cm depth of **FA 7** in a test-tube add 1 cm depth of aqueous silver nitrate,	
followed by dilute aqueous ammonia.	
To a 1 cm depth of **FA 7** in a test-tube add 1 cm depth of either aqueous barium chloride or aqueous barium nitrate,	
followed by dilute hydrochloric acid.	
To a 1 cm depth of **FA 7** in a test-tube add 1 cm depth of **FA 8**,	
followed by dilute hydrochloric acid.	

[3]

(ii) Suggest which pair of anions may be present in **FA 7**.

FA 7 contains ..... and ..... [2]

(iii) Suggest which cation may be present in **FA 8**.

FA 8 contains ..... [1]

(c) **FA 9** contains an aqueous solution of one of the following: methanoic acid, ethanoic acid or ethanal. Carry out the following tests in order to identify which organic compound is present.

test	observation
To a 1 cm depth of **FA 9** in a test-tube add a few drops of acidified potassium manganate(VII). Stand the test-tube in the hot water-bath.	
To a 1 cm depth of **FA 9** in a test-tube add a half spatula measure of solid sodium hydrogen carbonate.	

FA 9 contains .....

Explain your reasoning.

.....

..... [3]

[Total: 16]

4. Epsom salts occur naturally and are a hydrated form of magnesium sulfate, $MgSO_4.xH_2O$.

In the following experiment you will determine the value of *x*.
Read all of the following instructions before you start any experimental work.

You are provided with the following:
FA 1 hydrated magnesium sulfate, $MgSO_4.xH_2O$

Method

1. Weigh a clean, dry crucible.
2. In the crucible place the entire sample of Epsom salts, **FA 1**.
3. Reweigh the crucible.
4. Place the crucible in a 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 for about 1 minute and then use a pair of tongs to place the crucible on a heat proof mat.
7. Leave the crucible to cool for approximately three minutes, then reweigh the crucible and its contents.
8. Repeat the cycle of heating and weighing, as described in steps 4 to 7, until consecutive recorded masses do not differ by more than 0.05 g.

(a) In a suitable table, record all masses.
Calculate the mass of the residue and the mass of the water lost. Record both of these masses in the table.

[8]

(b) From the measurements you have made, determine the value of x in the formula $MgSO_4.xH_2O$.

Show your working.

.....[4]

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

uncertainty = ± ..... g [1]

(ii) Calculate the percentage error in the mass of water that is lost.

Show your working.

.....[2]

(d) Suggest an improvement that a student might make to the experiment and explain why this would lead to the determination of a more accurate value of x.

.....

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.....[2]

[Total: 17]