Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

7987260206

CHEMISTRY **9701/51**

Paper 5 Planning, Analysis and Evaluation **May/June 2021**

1 hour 15 minutes

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working, use appropriate units and use an appropriate number of significant figures.

INFORMATION

- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **8** pages. Any blank pages are indicated.

[Turn over

1 Hydrogen peroxide decomposes slowly at room temperature to give water and oxygen.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The **initial** rate of this reaction can be increased by the addition of a metal oxide catalyst.

A student is asked to investigate which metal oxide catalyst is best at increasing the **initial** rate of this reaction by using a method which involves the collection of oxygen.

The student is provided with the following metal oxides: copper(II) oxide, iron(III) oxide, manganese(IV) oxide, nickel(II) oxide and titanium(IV) oxide.

The student is also provided with an excess volume, of a known concentration, of aqueous hydrogen peroxide and any laboratory equipment needed.

(a) (i) State the independent variable.

..... [1]

(ii) State the dependent variable.

..... [1]

(b) State two variables that would need to be controlled.

1 .....

2 .....

[2]

(c) Draw a labelled diagram of the assembled apparatus that could be used to carry out these experiments. The apparatus should allow the accurate recording of the oxygen produced.

[3]

(d) (i) What measurements need to be recorded during the course of each experiment to allow the **initial** rate to be determined?

..... [1]

(ii) How is the **initial** rate determined using these measurements?

.....

..... [1]

(e) How can the student ensure that the results are reliable?

..... [1]

(f) Suggest an alternative method to investigate these reactions which does not include the collection of gas.

.....

..... [1]

(g) Once the reaction has finished, how can the student demonstrate that the metal oxide has not been affected by the reaction?

.....

.....

.....

..... [2]

(h) When aqueous hydrogen peroxide is stored there is a small hole in the lid of the bottle.

Suggest why this is necessary.

.....

..... [1]

[Total: 14]

2 A student is given 250.0 cm^3 of solution containing a mixture of Fe^{2+} and Fe^{3+} ions. The student is asked to find the total mass of iron ions and the percentage by mass of Fe^{3+} in the solution by performing titrations with aqueous potassium manganate(VII), $KMnO_4$.

The student is told that the $Fe^{3+}(aq)$ ions can be reduced to $Fe^{2+}(aq)$ ions by reaction with zinc.

The student is given the following instructions.

- Calculate the mass of $KMnO_4$ needed to make 500.0 cm^3 of 0.0200 mol dm^{-3} $KMnO_4(aq)$.
- Record the mass of an empty plastic weighing boat (a small container used to hold solid samples).
- Add the calculated mass of $KMnO_4$ to the weighing boat.
- Transfer the $KMnO_4$ from the weighing boat into a 100 cm^3 beaker.
- Add 50 cm^3 of distilled water to the beaker.
- Transfer the mixture from the beaker into a 500.0 cm^3 volumetric flask.
- Make up to the graduation mark, dropwise, with distilled water.

(a) (i) Calculate the mass of $KMnO_4$ needed to make 500.0 cm^3 of 0.0200 mol dm^{-3} $KMnO_4(aq)$.

[A_r: K, 39.1; Mn, 54.9; O, 16.0]

mass of $KMnO_4$ needed = ... g [1]

(ii) The student used a balance accurate to two decimal places.

Calculate the percentage error in weighing the mass of the $KMnO_4$ by difference.

If you were unable to calculate a value for **2(a)(i)** use the mass 1.75 g. This is **not** the correct answer to **2(a)(i)**. Show your working.

percentage error = ... % [1]

(iii) The student noticed that some crystals of $KMnO_4$ were stuck to the weighing boat after adding the $KMnO_4$ solid to the beaker.

State how the student should modify the instructions to ensure that the measured mass of $KMnO_4$ was accurate.

.....

.....

..... [1]

(iv) Give two additional instructions that should be given to the student to ensure that the solution is prepared as accurately as possible.

1 .....

.....

2 .....

.....

[2]

(b) When the $KMnO_4(aq)$ is ready for use, the student is given additional instructions.

step 1 Fill a burette with 0.0200 mol dm^{-3} $KMnO_4(aq)$.

step 2 Using a measuring cylinder, transfer 25.00 cm^3 of $Fe^{2+}(aq)/Fe^{3+}(aq)$ solution into a conical flask.

step 3 Add 10 cm^3 of 1.0 mol dm^{-3} sulfuric acid to the conical flask.

step 4 Titrate this acidified solution of $Fe^{2+}(aq)/Fe^{3+}(aq)$ with 0.0200 mol dm^{-3} $KMnO_4(aq)$ until the end-point.

step 5 Repeat titrations until the titres are concordant.
This set of results is **set A**.

step 6 Using a measuring cylinder, add 100 cm^3 of the $Fe^{2+}(aq)/Fe^{3+}(aq)$ solution into a beaker then add excess zinc. Allow time for reduction to $Fe^{2+}(aq)$ to take place.

step 7 Filter the mixture into a beaker.

step 8 Transfer 25.00 cm^3 of the filtrate into a conical flask and add 10 cm^3 of 1.0 mol dm^{-3} sulfuric acid.

step 9 Titrate this acidified solution of the filtrate with 0.0200 mol dm^{-3} $KMnO_4(aq)$ until the end-point.

step 10 Repeat **steps 8** and **9** twice.
This set of results is **set B**.

(i) How should the burette be prepared for use before it is filled in **step 1**?

.....

..... [1]

(ii) What must be done to ensure as accurate an end-point as possible?

.....

..... [1]

(c) (i) Identify an experimental weakness in **step 2**. Explain how this would affect the results.

.....

.....

..... [1]

(ii) How could this weakness be overcome?

..... [1]

(d) The results for each set of titrations are shown.

set A

	rough	titration 1	titration 2	titration 3
final volume / cm^3	18.40	17.25	34.55	18.00
initial volume / cm^3	0.65	0.15	17.25	0.95
titre / cm^3				

set B

	rough	titration 1	titration 2	titration 3
final volume / cm^3	45.05	43.60	43.70	
initial volume / cm^3	0.20	0.15	0.10	
titre / cm^3				

(i) Complete both tables and calculate an appropriate average titre for each set of results. The student could **not** carry out titration 3 in **set B**.

Record the average titre to **one decimal place**.

set A average titre = ... cm^3

set B average titre = ... cm^3

[2]

(ii) The reaction taking place during the titrations is shown by the equation.

$$MnO_4^-(aq) + 5Fe^{2+}(aq) + 8H^+(aq) \rightarrow Mn^{2+}(aq) + 5Fe^{3+}(aq) + 4H_2O(l)$$

Calculate the mass of Fe^{2+} ions in 100 cm^3 of the reduced solution, produced in **step 6**, by using the appropriate average titre from **(d)(i)**.

Give your answer to **three significant figures**.

[A_r: Fe, 55.8]

mass of Fe^{2+} ions = ... g [2]

(iii) Calculate the mass of Fe^{2+} ions in the original 250.0 cm^3 $Fe^{2+}(aq)/Fe^{3+}(aq)$ solution, using the appropriate average titre from **2(d)(i)**.

mass of Fe^{2+} ions = ... g [1]

(iv) Calculate the percentage by mass of Fe^{3+} ions in the original 250.0 cm^3 $Fe^{2+}(aq)/Fe^{3+}(aq)$ solution.

percentage by mass of Fe^{3+} ions = ... % [1]

(v) State what change could be made to the procedure to enable titration 3 to be carried out in **set B**.

.....

..... [1]

[Total: 16]

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