



Cambridge International AS & A Level

CANDIDATE
NAME
CENTRE
NUMBER

--	--	--	--	--

CANDIDATE
NUMBER

--	--	--	--

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

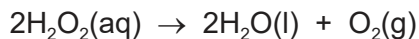
- The total mark for this paper is 30.
- The number of marks for each question or part question is shown in brackets [].

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



2

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



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]

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]

4

- 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 $\text{Fe}^{3+}(\text{aq})$ ions can be reduced to $\text{Fe}^{2+}(\text{aq})$ 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 $0.0200\text{ mol dm}^{-3}$ $\text{KMnO}_4(\text{aq})$.
- 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 $0.0200\text{ mol dm}^{-3}$ $\text{KMnO}_4(\text{aq})$.

[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]

5

- (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 $\text{KMnO}_4(\text{aq})$ is ready for use, the student is given additional instructions.

step 1 Fill a burette with $0.0200 \text{ mol dm}^{-3} \text{ KMnO}_4(\text{aq})$.

step 2 Using a measuring cylinder, transfer 25.00 cm^3 of $\text{Fe}^{2+}(\text{aq})/\text{Fe}^{3+}(\text{aq})$ 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 $\text{Fe}^{2+}(\text{aq})/\text{Fe}^{3+}(\text{aq})$ with $0.0200 \text{ mol dm}^{-3} \text{ KMnO}_4(\text{aq})$ 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 $\text{Fe}^{2+}(\text{aq})/\text{Fe}^{3+}(\text{aq})$ solution into a beaker then add excess zinc. Allow time for reduction to $\text{Fe}^{2+}(\text{aq})$ 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 $0.0200 \text{ mol dm}^{-3} \text{ KMnO}_4(\text{aq})$ 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]

6

- (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**.

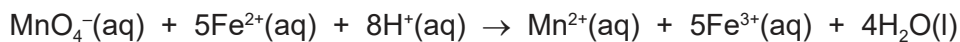
Record the average titre to **one decimal place**.

set A average titre = cm³

set B average titre = cm³
 [2]

7

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



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 $\text{Fe}^{2+}(\text{aq})/\text{Fe}^{3+}(\text{aq})$ 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 $\text{Fe}^{2+}(\text{aq})/\text{Fe}^{3+}(\text{aq})$ 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]

BLANK PAGE

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included, the publisher will be pleased to make amends at the earliest possible opportunity.

To avoid the issue of disclosure of answer-related information to candidates, all copyright acknowledgements are reproduced online in the Cambridge Assessment International Education Copyright Acknowledgements Booklet. This is produced for each series of examinations and is freely available to download at www.cambridgeinternational.org after the live examination series.

Cambridge Assessment International Education is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of the University of Cambridge Local Examinations Syndicate (UCLES), which itself is a department of the University of Cambridge.