Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Thursday 26 October 2023

Morning (Time: 1 hour 20 minutes)

Paper reference **WCH16/01**

Chemistry

International Advanced Level

UNIT 6: Practical Skills in Chemistry II

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 7 4 3 1 4 R A 0 1 2 0

Pearson

Answer ALL the questions. Write your answers in the spaces provided.

1 A series of tests is carried out on a violet-coloured solid **A**, which contains two cations and one anion.

(a) Some solid calcium oxide is added to a spatula measure of **A** in a test tube and the mixture heated gently.

A pungent gas is given off which turns damp red litmus paper blue.

(i) Give the name or formula of the gas produced in this test.

(1)

.....

(ii) Give the **formula** of the cation in **A** shown by this test.

(1)

.....

(b) Alkaline solutions are added drop by drop to separate samples of an aqueous solution of **A** until there is no further reaction.

With dilute sodium hydroxide, a green precipitate forms which dissolves in excess sodium hydroxide giving a green solution.

With dilute aqueous ammonia, a green precipitate forms which dissolves in excess ammonia giving a violet solution.

(i) State the **types** of reaction that occur when the precipitates dissolve.

(2)

with excess sodium hydroxide .....

.....

with excess ammonia .....

.....

(ii) Give the **formula** of the cation in **A**, shown by the tests in (b).

(1)

.....

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(c) An aqueous solution of **A** is acidified with dilute hydrochloric acid, and a few drops of barium chloride solution are added.
A white precipitate forms.

(i) Give the **formula** of the anion in **A** shown by this test.

(1)

.....

(ii) State the reason for adding the dilute hydrochloric acid.

(1)

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(d) Suggest a formula for compound **A**, using your answers to (a), (b) and (c).

(1)

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(Total for Question 1 = 8 marks)

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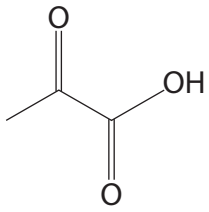
2 Compounds **B** and **C** are isomers with the molecular formula $C_3H_4O_3$.

Compound **B** is a colourless liquid with the structure shown.



(a) Name the functional groups present in **B**.

(2)

.....

.....

(b) A series of tests is carried out on **B**.

Complete the observation boxes.

(i) $2\,cm^3$ of aqueous sodium hydrogencarbonate, $NaHCO_3(aq)$, is added to a test tube containing a small quantity of **B**.

(1)

Observation

(ii) A few drops of **B** are added to $2\,cm^3$ of acidified potassium dichromate(VI) solution. The mixture is placed in a warm water bath.

(1)

Observations	
Initial colour	Final colour

(iii) A few drops of **B** are added to 2 cm^3 of a solution of 2,4-dinitrophenylhydrazine (Brady's reagent).

(1)

Observation

(iv) A few drops of **B** are added to 2 cm^3 of Fehling's solution. The mixture is placed in a warm water bath.

(1)

Observations	
Initial appearance of mixture	Final appearance of mixture

(v) A few drops of **B** are added to 2 cm^3 of a solution of iodine dissolved in aqueous sodium hydroxide solution. The mixture is placed in a warm water bath.

(1)

Observation

(c) Compound **C**, $C_3H_4O_3$, is also a colourless liquid.

C is non-cyclic and does **not** contain a carbon-carbon double bond.

C has a significantly lower boiling temperature than **B**.

C does **not** react with phosphorus(V) chloride, PCl_5.

C reacts with Tollens' reagent to produce a silver mirror.

Draw the displayed formula of a possible structure of **C**, using this information.

(2)

Possible structure of **C**

(Total for Question 2 = 9 marks)

3 This question is about ethanedioic acid, $(COOH)_2$, also known as oxalic acid. Traces of ethanedioic acid are found in many foods including spinach, fruits, nuts and seeds.

A group of students carried out an experiment to determine the percentage by mass of ethanedioic acid in rhubarb leaves.

(a) The first stage of the experiment was the extraction of ethanedioic acid.

319 g of rhubarb leaves was chopped up and placed into a large beaker of distilled water. The mixture was boiled gently for about 15 minutes and then filtered. The solution was transferred to a volumetric flask and the volume made up to exactly 1000.0 cm^3 with distilled water and mixed thoroughly. This solution was labelled **R**.

One student suggested that hexane should be used as the solvent rather than water.

Explain why water is used as a solvent and not hexane.

(2)

(b) The second stage of the experiment was the titration of the ethanedioic acid solution **R**.

25.0 cm^3 portions of **R** were placed in conical flasks and titrated with **either** aqueous sodium hydroxide, NaOH, **or** aqueous cerium(IV) sulfate, $Ce(SO_4)_2$.

The equations for these reactions are

$$2NaOH(aq) + (COOH)_2(aq) \rightarrow Na_2(COO)_2(aq) + 2H_2O(l)$$

$$2Ce^{4+}(aq) + (COOH)_2(aq) \rightarrow 2Ce^{3+}(aq) + 2CO_2(g) + 2H^+(aq)$$

$Ce^{4+}(aq)$ ions have a yellow colour and $Ce^{3+}(aq)$ ions are colourless.

(i) For each of these titrations, describe how the end-point can be detected, stating the colour changes in each case.

(3)

(ii) Some of the students decided to titrate 25.0 cm^3 portions of solution **R** with 0.0400 mol dm^{-3} aqueous sodium hydroxide.

The mean titre was 20.60 cm^3.

Calculate the percentage, by mass, of ethanedioic acid in this sample of rhubarb leaves.
Give your answer to an appropriate number of significant figures.

[Molar mass $(COOH)_2$ = 90.0 g mol^{-1}]

(5)

(c) Ethanedioic acid is used in many laboratories. It is usually supplied as hydrated crystals, $(COOH)_2 \cdot \mathbf{x}H_2O$, and dissolved in distilled water to make a solution.

A technician makes 500 cm^3 of a 0.500 mol dm^{-3} ethanedioic acid solution by dissolving 31.5 g of hydrated ethanedioic acid and making the volume up to 500 cm^3 with distilled water.

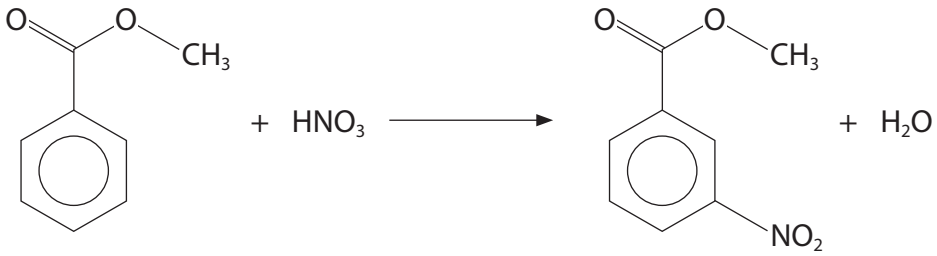
Calculate the value of **x** in the formula of hydrated ethanedioic acid, $(COOH)_2 \cdot \mathbf{x}H_2O$.

(3)

(Total for Question 3 = 13 marks)

4 This question is about the nitration of methyl benzoate.

The equation for the reaction is shown.



Procedure

Step **1** Weigh between 1.9 g and 2.1 g of methyl benzoate in a 50 cm^3 conical flask.

Step **2** Slowly add 5 cm^3 of concentrated sulfuric acid to the methyl benzoate with swirling and place the flask in an ice-water bath to cool.

Step **3** Place 2.0 cm^3 of concentrated nitric acid into a test tube.
Cool the nitric acid by immersing the test tube in an ice-water bath before slowly adding 2.0 cm^3 of concentrated sulfuric acid.
Allow this nitrating mixture to cool.

Step **4** Using a teat pipette, add the nitrating mixture very slowly to the conical flask, ensuring the temperature does not exceed 7°C.

Step **5** Allow the flask to stand at room temperature for about 15 minutes and then pour the contents into a beaker containing some crushed ice.
Impure methyl 3-nitrobenzoate will form.

Step **6** Recrystallise the methyl 3-nitrobenzoate using methanol as the solvent.

Step **7** Weigh the dry crystals and determine their melting temperature.

(a) A bottle of concentrated nitric acid has two hazard warning signs.

(i) State the two hazards.

(1)

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(ii) Give a precaution to reduce the risk when using concentrated nitric acid. Assume that safety goggles and a laboratory coat are used.

(1)

(b) Explain why the nitrating mixture is added slowly in Step **4**.

(2)

(c) During recrystallisation in Step **6**, the methyl 3-nitrobenzoate is dissolved in a minimum volume of hot methanol and the hot mixture filtered.
The filtrate is cooled, and the resulting crystals filtered and rinsed with ice-cold methanol.

(i) State why methanol is a suitable solvent for use in the recrystallisation of methyl 3-nitrobenzoate.

(1)

(ii) State the purpose of each of the filtrations during the recrystallisation of methyl 3-nitrobenzoate.

(2)

(iii) Give the purpose of rinsing the crystals, stating why the methanol is ice-cold.

(2)

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(d) 1.95 g of methyl benzoate reacted with an excess of nitric acid to form 1.51 g of methyl 3-nitrobenzoate.

[Molar mass values: methyl benzoate, $C_6H_5CO_2CH_3 = 136\,g\,mol^{-1}$
methyl 3-nitrobenzoate, $C_6H_4CO_2CH_3NO_2 = 181\,g\,mol^{-1}$]

(i) Calculate the percentage yield.

(2)

(ii) Give **one** possible reason why the yield in (d)(i) is less than 100%.

(1)

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(Total for Question 4 = 12 marks)

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5 A group of students carried out a series of experiments to investigate the kinetics of the reaction between hydrogen peroxide and iodide ions in acidic conditions.

The equation for the reaction is shown.

$$H_2O_2(aq) + 2H^+(aq) + 2I^-(aq) \rightarrow 2H_2O(l) + I_2(aq)$$

Procedure

Step **1** Measure 10 cm^3 of aqueous sodium thiosulfate solution into a conical flask. Add 5 cm^3 of aqueous starch solution and 25 cm^3 of distilled water.

Step **2** Measure 5 cm^3 of aqueous potassium iodide solution and 5 cm^3 of dilute sulfuric acid and add these to the mixture in the conical flask from Step **1**.

Step **3** Measure 5 cm^3 of aqueous hydrogen peroxide solution into a test tube.

Step **4** Add the hydrogen peroxide solution to the conical flask, mix thoroughly and start the timer.

Step **5** Record the time when the solution turns blue-black.

Step **6** Repeat the experiment varying the volumes of aqueous potassium iodide solution and distilled water, keeping the total volume of the mixture constant.

(a) Explain the purpose of adding the sodium thiosulfate solution in Step **1**.

(2)

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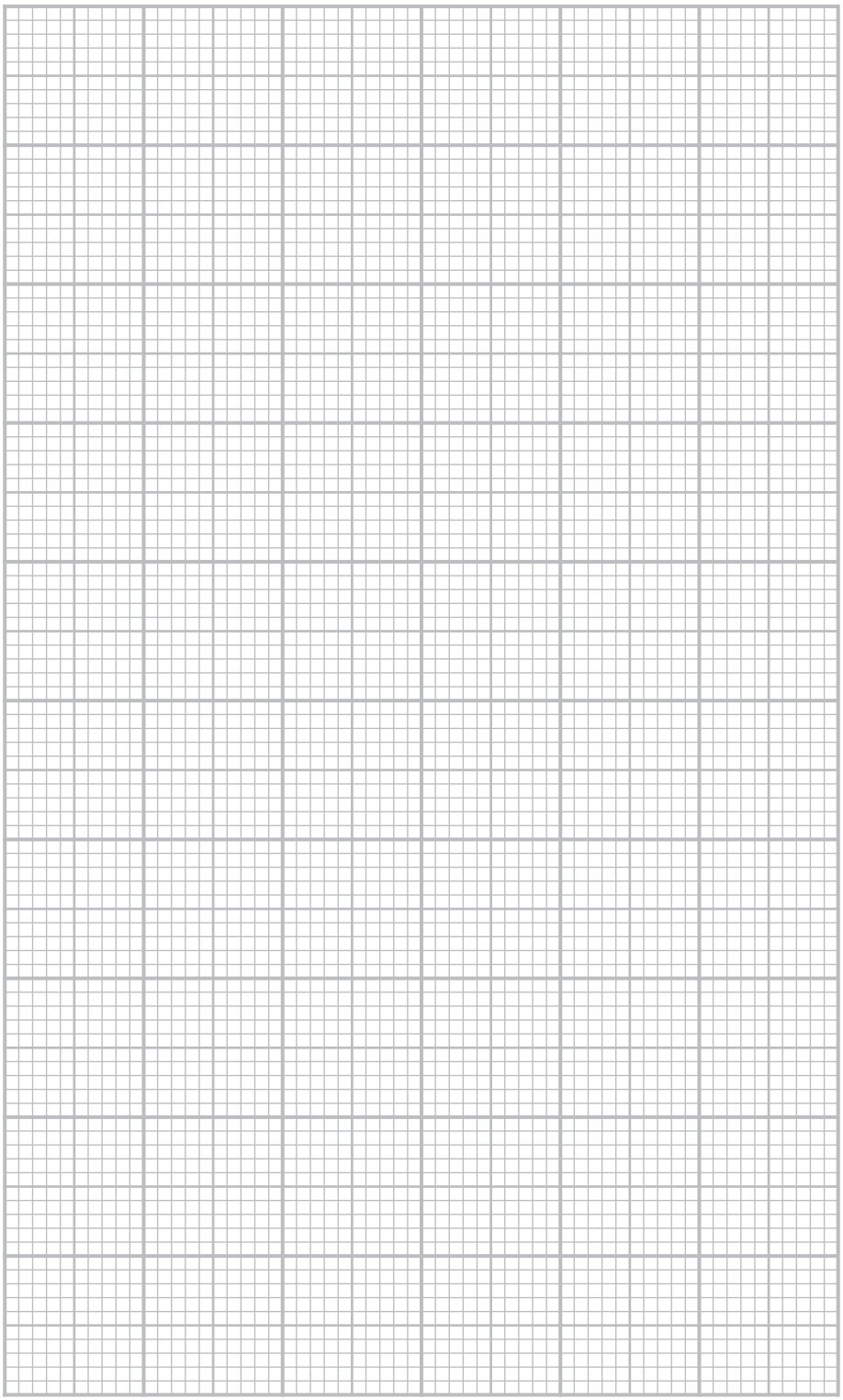
.....

(b) A set of results is shown.

Run	Volume of solutions / cm^3						Time (t) / s	1 / t / s^{-1}
	$Na_2S_2O_3$	Starch	H_2O	KI	H_2SO_4	H_2O_2		
1	10	5	25	5	5	5	270	0.0037
2	10	5	20	10	5	5	138	0.0072
3	10	5	15	15	5	5	93	0.011
4	10	5	10	20	5	5	71	0.014
5	10	5	5	25	5	5	55	0.018

(i) Plot a graph of 1 / t against the volume of potassium iodide.

(3)



(ii) Deduce the order of the reaction with respect to iodide ions, using your graph. Justify your answer.

(2)

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(c) Give a reason why the concentration of the potassium iodide solution is significantly lower than that of the hydrogen peroxide solution and the sulfuric acid.

(1)

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(Total for Question 5 = 8 marks)

TOTAL FOR PAPER = 50 MARKS

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