Cambridge Assessment International Education

Cambridge International AS & A Level

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8469838198

CHEMISTRY **9701/23**

Paper 2 AS Level Structured Questions **May/June 2021**

1 hour 15 minutes

You must answer on the question paper.

You will need: Data booklet

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 60.
- The number of marks for each question or part question is shown in brackets [ ].

This document has **12** pages. Any blank pages are indicated.

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[Turn over

Answer **all** the questions in the spaces provided.

1 The elements in Group 17 are known as the halogens.

(a) Between the molecules of Group 17 elements van der Waals' forces exist.

(i) State the trend in the relative strength of van der Waals' forces down Group 17.

..... [1]

(ii) State the physical state of each of the halogens under room conditions.

chlorine .....

bromine .....

iodine .....

[1]

(b) A solution of aqueous bromide ions, $Br^-(aq)$, is added to separate samples of $Cl_2(aq)$ and $I_2(aq)$.

Describe what is observed in each reaction. Explain your answer in terms of the relative reactivity of these elements as oxidising agents.

observation on addition to $Cl_2(aq)$ .....

.....

observation on addition to $I_2(aq)$ .....

.....

explanation .....

.....

.....

[3]

(c) Bleach is made by reacting Cl_2 with cold NaOH(aq).

Write an equation for the reaction of Cl_2 with cold NaOH.

..... [1]

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(d) When $C\ell O^-(aq)$ is added to water, it behaves as a Brønsted-Lowry base.

(i) Define the term *Brønsted-Lowry base*.

..... [1]

(ii) Write an ionic equation for the reaction between $C\ell O^-$ and H_2O.

..... [1]

(e) The concentration of $NaC\ell O$ in bleach **S** is x g dm^{-3}.

$NaC\ell O$ reacts with $H_2O_2(aq)$ as shown.

$$H_2O_2(aq) + NaC\ell O(aq) \rightarrow H_2O(l) + NaC\ell(aq) + O_2(g)$$

A 5.00 cm^3 sample of **S** completely reacts with $H_2O_2(aq)$. The volume of $O_2(g)$ produced is 24.0 cm^3 under room conditions.

Assume that only the $NaC\ell O$ in **S** reacts with $H_2O_2(aq)$.

Calculate x. Show your working.

x = ... g dm^{-3}
[3]

(f) Sodium chlorate(I), $NaC\ell O$, oxidises dilute hydrochloric acid to form three products. The products which contain chlorine have chlorine species with oxidation number –1 or 0.

No other species changes its oxidation number during the reaction.

Use this information to complete the ionic equation.

.....$C\ell O^-$ + ...$HC\ell \rightarrow$ ..... + ... + ... [2]

[Total: 13]

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2 Methanol, CH_3OH, is soluble in water because it forms hydrogen bonds with water molecules.

(a) Draw a fully labelled diagram to show how a hydrogen bond forms between a water molecule and a methanol molecule.

[3]

(b) Methanol has a melting point of –97.6 °C and a boiling point of 64.7 °C.

A sample of pure liquid methanol is added to a flask and then sealed. The sealed flask is left for several days at constant temperature. The vapour pressure is then measured as 17 kPa.

(i) Describe what is meant by the term *vapour pressure of methanol*.

.....

.....

..... [2]

(ii) Explain why some of the liquid becomes a vapour.

.....

.....

..... [1]

(iii) Suggest and explain why the vapour pressure of water at room temperature is lower than the vapour pressure of methanol at room temperature. Refer to the correct intermolecular forces in your answer.

.....

.....

..... [2]

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(c) Methanol is made by reacting carbon monoxide with hydrogen.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

Carbon monoxide and hydrogen react at 1.0×10^7 Pa and 200 °C. Eventually the reaction mixture reaches dynamic equilibrium.

The table shows the amounts of each species present in the mixture.

	CO(g)	H_2(g)	CH_3OH(g)
initial amount / mol	1.0	2.0	0
equilibrium amount / mol	0.030	0.060	0.97

(i) Explain what is meant by *dynamic equilibrium*.

.....

.....

..... [2]

(ii) Calculate the partial pressure of methanol vapour at equilibrium under these conditions. Show your working.

..... Pa [2]

(iii) Write an expression for the equilibrium constant, K_p, for this reaction. State the units in your answer.

K_p =

units = ... [2]

[Total: 14]

3 Separate samples of **R**, **S**, **T** and **U** are added to cold water. The identity of each sample is unknown. However, each sample is known to be pure and can only be one of $Ba(OH)_2$, $NaCl$, P_4O_{10} or $SiCl_4$.

(a) (i) Use the observations in the table to identify each sample as one of $Ba(OH)_2$, $NaCl$, P_4O_{10} and $SiCl_4$. Write your answers in the table.

	state at room temperature	observations on addition of sample to water	identity of sample
R	solid	alkaline, colourless solution is produced, some white solid remains	
S	solid	white solid disappears, solution is neutral	
T	liquid	misty fumes produced, white solid is made in vigorous reaction	
U	solid	acidic, colourless solution produced in vigorous reaction	

[4]

(ii) Identify the formula of the white solid made when sample **T** reacts with water.

..... [1]

(iii) Name the solution formed when sample **U** reacts with water.

..... [1]

(b) Magnesium oxide and aluminium oxide have properties typical of ceramic materials.

(i) Name **one** physical property typical of ceramic materials.

..... [1]

(ii) Give the formula of another Period 3 oxide which behaves as a ceramic material.

..... [1]

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(c) Tungsten oxide, W_xO_y, is used to give colour to ceramic materials.

A sample of W_xO_y contains 79.29% tungsten by mass.

Calculate the empirical formula of W_xO_y.

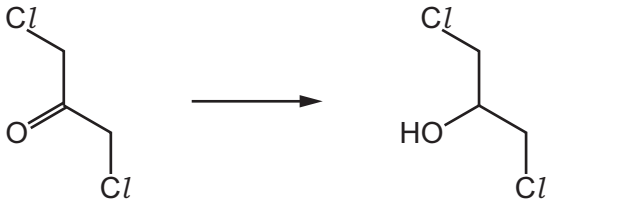
Show your working.

empirical formula = ...
[3]

[Total: 11]

4 **(a)** 1,3-dichloropropan-2-ol can be made by reacting **M**.

M 1,3-dichloropropan-2-ol



(i) Give the systematic name of **M**.

..... [1]

(ii) Name the functional group present in **M** that changes during this reaction.

..... [1]

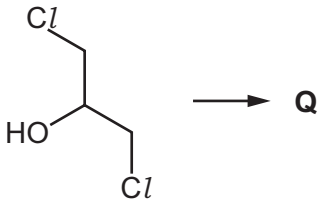
(iii) State a suitable reagent for this reaction.

..... [1]

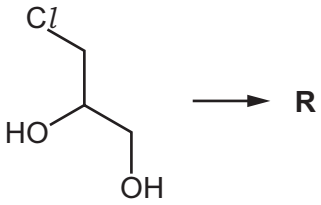
(b) Separate samples of 1,3-dichloropropan-2-ol and 3-chloropropane-1,2-diol are heated with excess acidified $Cr_2O_7^{2-}$ until there is no further reaction.

In each reaction, a different organic product, **Q** or **R**, is made.

1,3-dichloropropan-2-ol



3-chloropropane-1,2-diol



Q and **R** are tested separately with 2,4-dinitrophenylhydrazine solution, 2,4-DNPH, and sodium carbonate solution, $Na_2CO_3(aq)$.

Complete the table to give any relevant observations.

If no reaction occurs, write 'no visible change'.

reagent	observation with **Q**	observation with **R**
2,4-DNPH		
$Na_2CO_3(aq)$		

[4]

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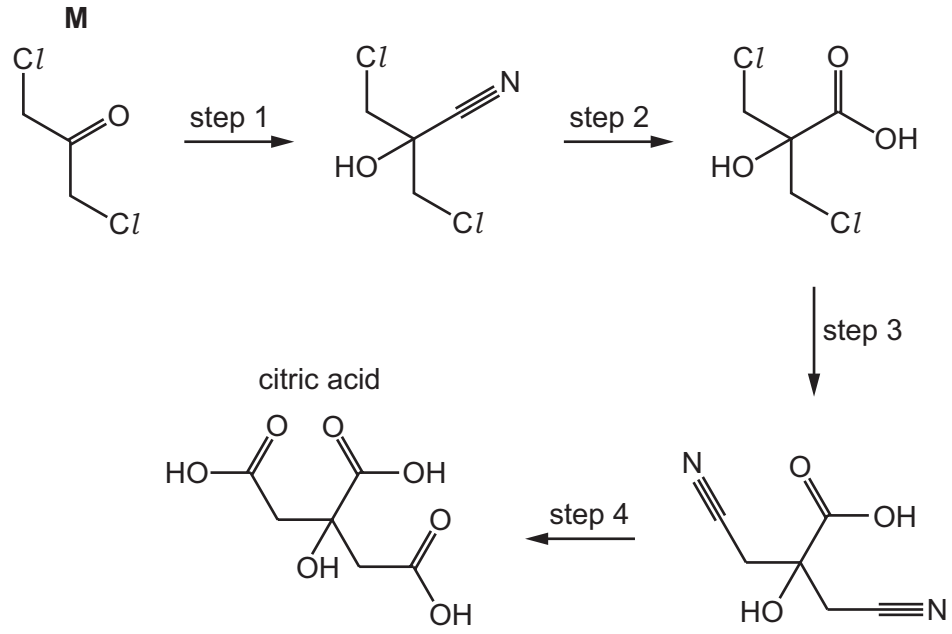
(c) Citric acid can be made from **M** in a four-step reaction.



Complete the table for each step of the reaction sequence to identify:

- the reagents and conditions required
- the type of reaction.

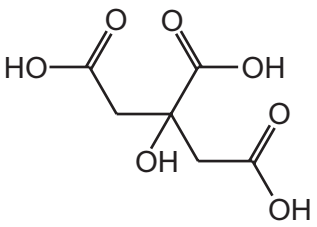
step	reagent and conditions	type of reaction
1		
2	dilute sulfuric acid	
3		
4	dilute sulfuric acid	

[5]

[Total: 12]

5 Compound **X** contains the same functional groups as citric acid.

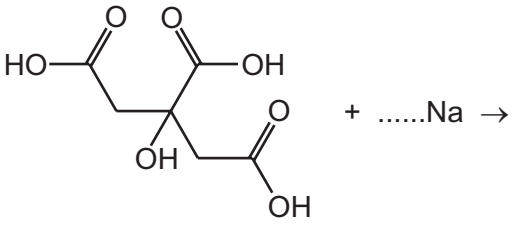
citric acid



The table describes some of the similarities and differences between citric acid and compound **X**.

	citric acid	**X**
chiral centre	no	yes
reaction with Na	fizzing	fizzing
reaction with $H^+/Cr_2O_7^{2-}$	remains orange	orange to green

(a) Complete the equation to show the reaction of excess sodium with citric acid. Show the skeletal structure of the product.



[3]

(b) (i) Use the information in the table to deduce the skeletal formula of **X**, $C_3H_6O_3$. Draw the skeletal formula of **X** in the box. Label the chiral centre of compound **X** with an asterisk (*).

[2]

(ii) Explain why compound **X** reacts with acidified $Cr_2O_7^{2-}$ but citric acid does not.

.....

.....

..... [2]

(c) Compound **X** is one of a pair of stereoisomers.

Stereoisomerism occurs when a molecule has at least one of two key features.

State the two key features that give rise to stereoisomerism.

1 .....

.....

2 .....

.....

[2]

(d) A structural isomer of compound **X** does not fizz when added to sodium.

Explain what is meant by *structural isomer*.

.....

..... [1]

[Total: 10]

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