Surname	Centre Number	Candidate Number
First name(s)		2

GCE AS/A LEVEL

S24-2410U10-1

2410U10-1

TUESDAY, 14 MAY 2024 – MORNING

CHEMISTRY – AS unit 1
The Language of Chemistry, Structure of Matter and Simple Reactions

1 hour 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 8.**	**10**	
Section B	**9.**	**15**	
	10.	**12**	
	11.	**14**	
	12.	**17**	
	13.	**12**	
	Total	**80**	

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01

ADDITIONAL MATERIALS

- A calculator, pencil and ruler
- **Data Booklet** supplied by WJEC

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Section A Answer **all** questions.
Section B Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The maximum mark for this paper is 80.

Your answers must be relevant and must make full use of the information given to be awarded full marks for a question.

The assessment of the quality of extended response (QER) will take place in **Q12**(a).

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SECTION A

Answer **all** questions.

1. State why chlorine is used in water treatment. [1]

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2. State the pattern in electronegativity across Period 3 in the Periodic Table. [1]

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3. Name the element in Period 3 that has a half-filled set of *p*-orbitals. [1]

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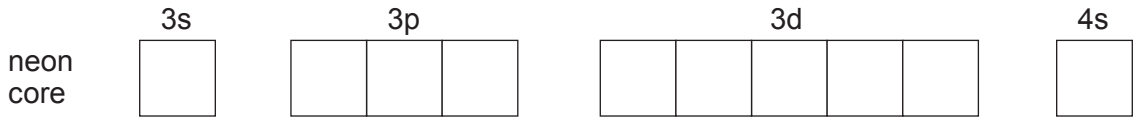
4. By inserting arrows to represent electrons, complete the electronic structure of a vanadium atom. [1]



5. Magnesium nitrate decomposes when heated to form magnesium oxide, nitrogen dioxide and oxygen.

Balance the equation for this reaction. [1]

..... $Mg(NO_3)_2$ ⟶ ..2.. MgO + ... NO_2 + ... O_2

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6. Consider the following species.

$^{16}_{8}O^{2-}$ $^{18}_{8}O$ $^{32}_{16}S^{2-}$

State whether you agree with the following statements, giving a reason for your conclusion.

(a) $^{32}_{16}S^{2-}$ has twice the number of neutrons that there are in $^{18}_{8}O$. [1]

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.....

(b) The sum of the number of electrons in $^{16}_{8}O^{2-}$ and $^{18}_{8}O$ is equal to the number of electrons in $^{32}_{16}S^{2-}$. [1]

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7. Hydrated copper(II) sulfate has the formula $CuSO_4.5H_2O$.

Calculate the number of moles of oxygen atoms present in 0.5 mol of hydrated copper(II) sulfate. [1]

Oxygen atoms = ... mol

8. A 0.717 g sample of gas occupies 1000 cm^3 at 273 K and 1 atm. Calculate the relative formula mass of the gas. [2]

Relative formula mass = ...

10

2410U101
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SECTION B

Answer **all** questions.

9. (a) The properties of elements and their compounds are determined by their structure and bonding.

(i) Diamond and graphite are allotropes of carbon.

I. Describe the structure and bonding in diamond and in graphite. Diagrams may be used as part of your answer. [2]

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II. State **one** physical property which is common to both diamond and graphite and **one** which is not. Explain **both** properties in terms of the structure and bonding you have described. [4]

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(ii) I. Draw a dot and cross diagram to show the formation of the bonding in sodium chloride. [2]

II. State why the crystal structures of sodium chloride and caesium chloride are different. [1]

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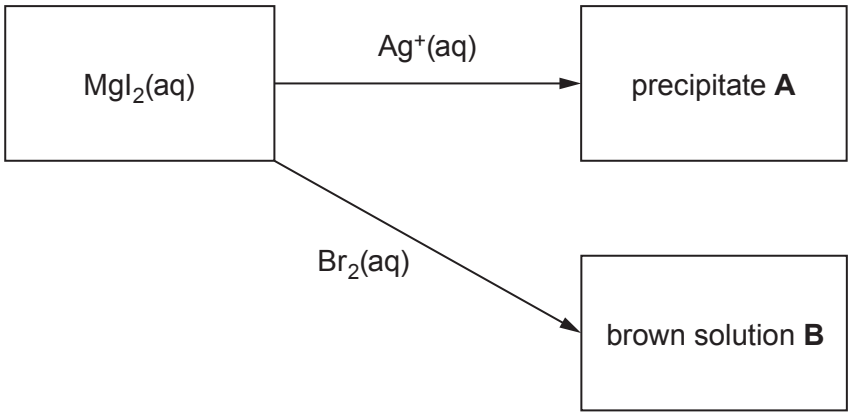
(b) Two reactions of aqueous magnesium iodide are given in the reaction scheme below.



(i) State the colour of precipitate **A** and give the **ionic** equation for its formation. [2]

Colour .....

Ionic equation .....

(ii) Name the product that gives solution **B** its brown colour and state the role of aqueous bromine in this reaction. [2]

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(c) Describe a chemical test, apart from a flame test, which would distinguish between aqueous solutions of magnesium iodide and barium iodide. Your answer should include the reagent(s) used and the observations made in each case. [2]

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15

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10. (a) Iodine-124 is an unstable radioactive isotope that decays by positron emission. It has a half-life of 4 days.

(i) Write an equation to show this decay. [2]

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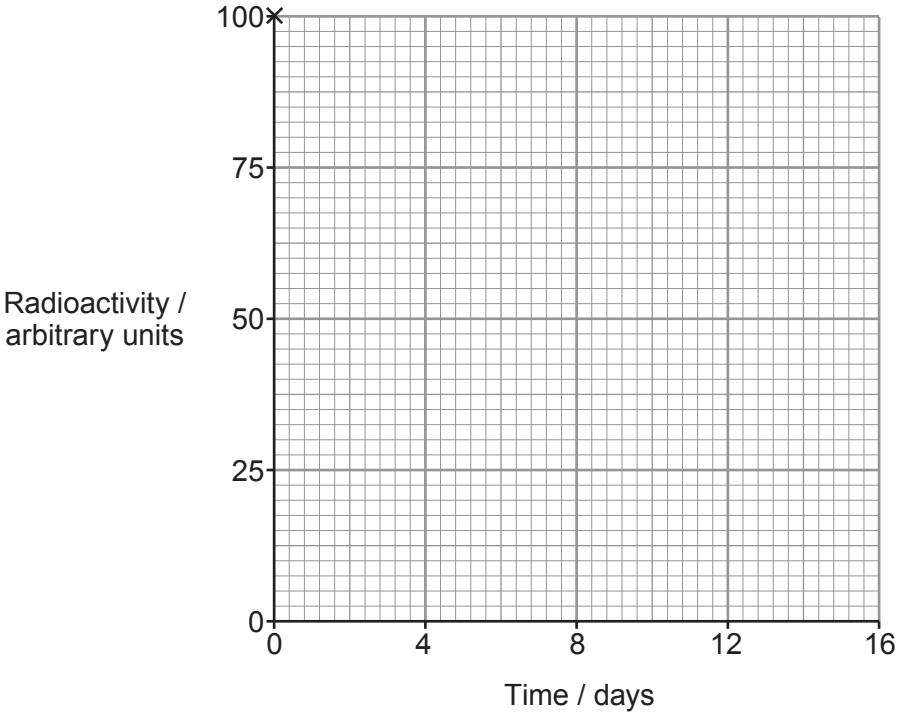
(ii) Complete the graph below to show how the radioactivity of a sample of iodine-124 would vary with time. [2]



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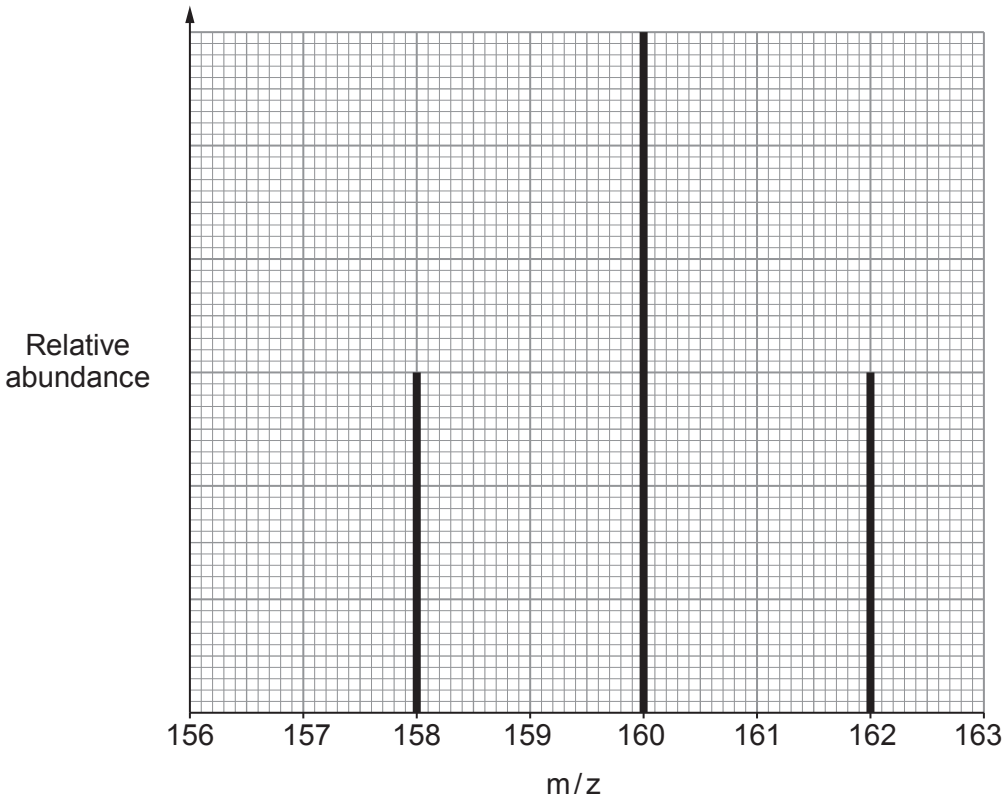
(b) The molecular ion region of the mass spectrum of bromine, Br_2, is shown below.



Explain the presence of the three peaks and why their height ratio is 1:2:1. [3]

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(c) A student was asked to find the pH of an acidic solution. She used a pH meter and found it to be 1.92.

(i) Calculate the hydrogen ion concentration of this solution. [1]

$[H^+]$ = ... $mol\,dm^{-3}$

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(ii) Since the pH meter had not been used for a while, the teacher wanted to check the accuracy of the reading.

He asked the student to check this by titrating 25.0 cm^3 of the acidic solution against standardised barium hydroxide solution and calculating the hydrogen ion concentration using the following equation.

$$Ba(OH)_2 + 2H^+ \longrightarrow Ba^{2+} + 2H_2O$$

These were the results.

Volume of acidic solution	25.0 cm^3
Concentration of $Ba(OH)_2$	5.02×10^{-3} mol dm^{-3}
Titre	23.55 cm^3

Use these results and the equation to calculate the number of moles of hydrogen ions, H^+, in 25.0 cm^3 of the acidic solution and hence the hydrogen ion concentration. [3]

$[H^+]$ = ... mol dm^{-3}

(iii) The student said that the reading on the pH meter was incorrect.
Do you agree? Justify your answer by comparing your answers to parts (i) and (ii). [1]

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12

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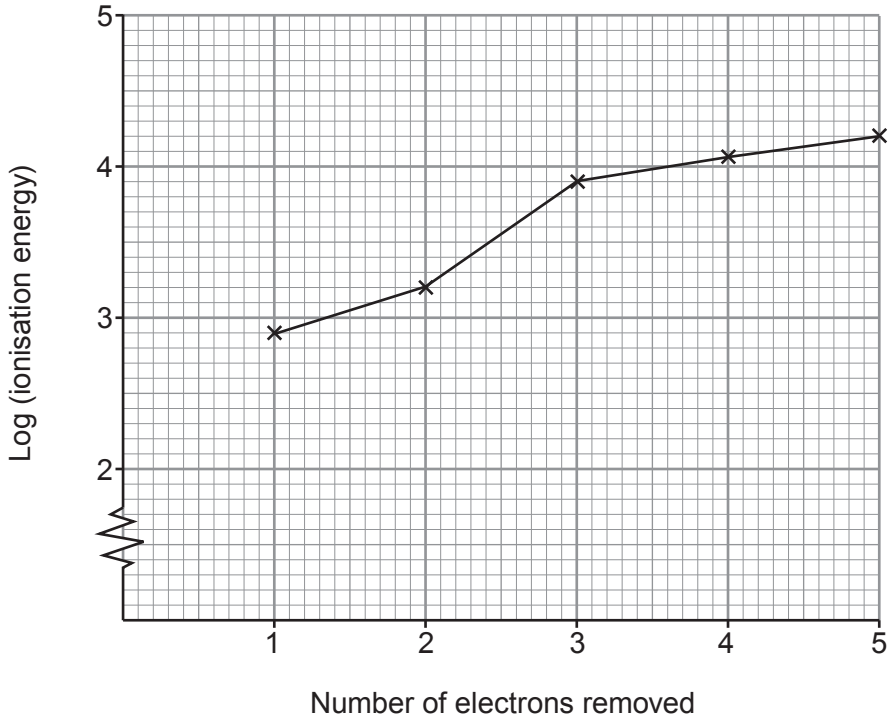
09

11. Two students were discussing how electrons affect ionisation energies and the shape of molecules.

(a) Elements **X**, **Y** and **Z** are in the same period of the Periodic Table. The graph below shows the first five ionisation energies of element **X**.



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(i) State how the graph shows that element **X** is in Group 2. [1]

.....

.....

(ii) Element **Y** has an atomic number one less than **X**, while element **Z** has an atomic number one more than **X**.

Since there is a general increase in first ionisation energies across a period, one student said:

"Element **X**'s first ionisation energy will be higher than that of element **Y** and lower than that of element **Z**."

Is he correct? Justify your answer by referring to both parts of his statement. [3]

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Examiner only

(b) (i) Write an equation to represent the second ionisation energy of sodium. Include state symbols. [1]

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(ii) The second ionisation energy of sodium is 4560 kJ mol^{-1}.

Calculate the value of the wavelength, in nm, of the radiation that corresponds to this energy change. [4]

Wavelength = ... nm

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(c) The second student said:

"When you consider CH_4, $AlCl_3$ and $BeCl_2$, the bond angle between the atoms in the molecule decreases as the number of bonds increases.

Therefore, the greater the number of bonds in any molecule the smaller the bond angle."

(i) State the bond angles in the molecules given above. [3]

H — $\hat{C}$ — H ..... °

Cl — $\hat{Al}$ — Cl ..... °

Cl — $\hat{Be}$ — Cl ..... °

(ii) Use your knowledge of VSEPR theory to explain why the second sentence is incorrect. Give an example to support your answer. [2]

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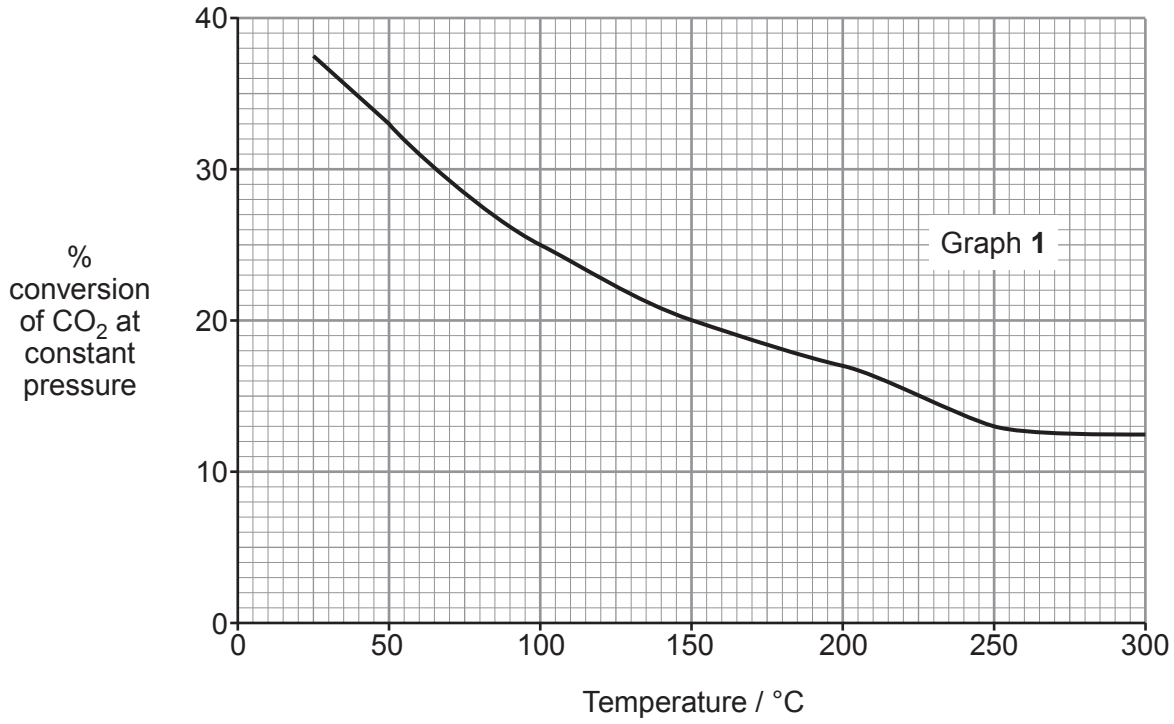
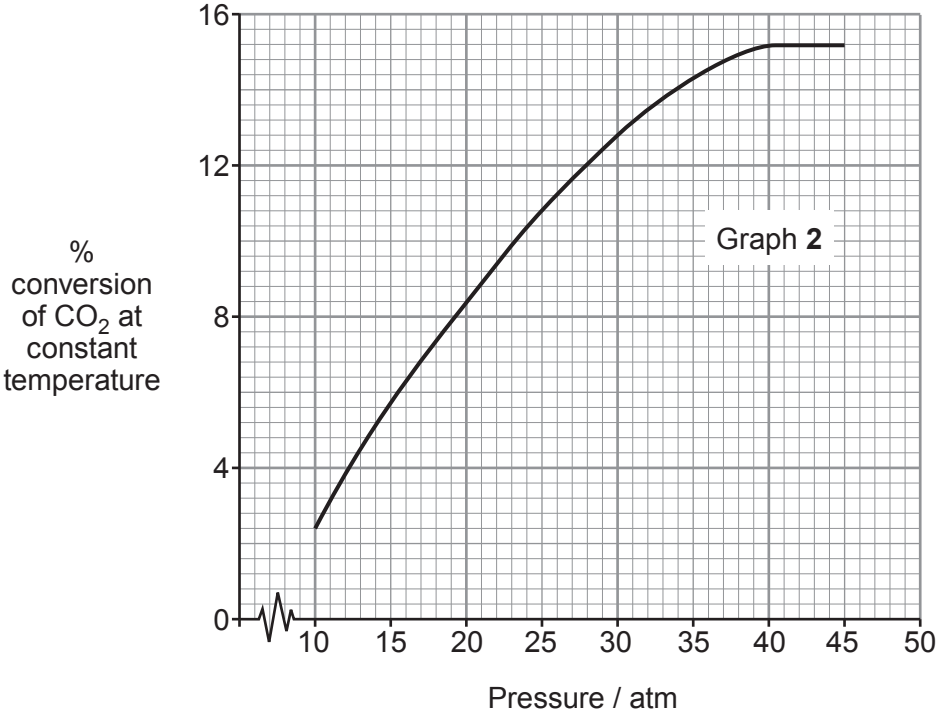
14

12. (a) There are several stages in the industrial production of methanol from methane.

The final stage involves an equilibrium where carbon dioxide is converted into methanol. The graphs below show the percentage conversion of carbon dioxide into methanol at **equilibrium** under different conditions of temperature and pressure.





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Equilibrium data is not the only information used when choosing the optimum temperature and pressure for the reaction.

Use the graphs and your knowledge to

- give as much information as possible about the reaction
- suggest optimum conditions for the reaction and indicate what further information is needed to make this judgment

Explain your reasoning throughout. [6 QER]

Examiner only

(b) The hydrogenation of carbon monoxide is a different method of producing methanol.

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

(i) Write an expression for the equilibrium constant, K_c, and give its unit, if any. [2]

K_c =

Unit .....

(ii) The equilibrium constant, K_c, has a numerical value of 0.350 at a temperature of 350 °C.

If the equilibrium concentration of carbon monoxide is 0.725 mol dm^{-3} and that of hydrogen is 0.850 mol dm^{-3}, calculate the equilibrium concentration of methanol at this temperature. [2]

Concentration = ... mol dm^{-3}

Examiner only

(c) Carbon monoxide is used in the reduction of iron(III) oxide in the blast furnace.

$$Fe_2O_3(s) + 3CO(g) \longrightarrow 2Fe(l) + 3CO_2(g)$$

(i) Calculate the atom economy for the formation of iron in this reaction. Give your answer to an **appropriate** number of significant figures. [3]

Atom economy = ... %

(ii) Calculate the volume, in m^3, of carbon dioxide that would be produced if 20 tonnes of iron(III) oxide were reduced at a temperature of 1100 °C and a pressure of 1 atm. [4]

Volume = ... m^3

17

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13. Sodium sesquicarbonate is a white crystalline solid which is used in bath salts, water treatment and as a cleaning and laundry product. Its formula can be represented as follows.

$$Na_2CO_3.\boldsymbol{x}NaHCO_3.\boldsymbol{y}H_2O$$

A student is asked to carry out an experiment to find the value of $\boldsymbol{x}$ using the following double titration method.

- Weigh out accurately about 1.7 g of sodium sesquicarbonate using a two-decimal place balance. Dissolve and make up to 250 cm^3 in a volumetric flask in the usual way.
- Measure 25.0 cm^3 of this solution into a conical flask and add a small amount of phenolphthalein indicator.
- Add 0.100 mol dm^{-3} hydrochloric acid from a burette whilst swirling the mixture until the phenolphthalein changes colour from **pink to colourless**.
- Record the results.
- Add a few drops of methyl orange indicator and continue titrating until the methyl orange changes colour from **yellow to orange**.
- Record the results.

The results of the titrations are shown below.

		1	2	3	4
With phenolphthalein (**A**)	Final volume / cm^3	7.80	30.70	7.75	30.25
	Initial volume / cm^3	0.00	23.30	0.30	22.75
	Titre **A** / cm^3	7.80	.....	.....	.....
With methyl orange (**B**)	Final volume / cm^3	23.30	45.60	22.75	45.10
	Initial volume / cm^3	7.80	30.70	7.75	30.25
	Titre **B** / cm^3	15.50	.....	.....	.....

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(a) Complete the table and calculate the mean titre at the phenolphthalein end-point (**A**) and the mean titre at the methyl orange end-point (**B**). [3]

Mean titre **A** = ... cm^3

Mean titre **B** = ... cm^3

(b) Name the piece of apparatus the student should have used to transfer 25.0 cm^3 of the solution into the conical flask. [1]

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(c) The percentage error due to the burette in the first titration with phenolphthalein is just over 1%. Suggest what the student could have changed in the method to halve this figure. [1]

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(d) Despite having a larger percentage error due to the burette, suggest a reason why mean titre **A** could be more accurate than mean titre **B**. [1]

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Examiner only

(e) (i) The equation for the reaction taking place in the phenolphthalein titration is as follows.

$$CO_3^{2-} + H^+ \longrightarrow HCO_3^-$$

Mean titre **A** is the volume needed to convert all the carbonate ions present to hydrogencarbonate ions.

Use this information and the student's results to calculate the number of moles of carbonate present in the original solution. [1]

$n(Na_2CO_3)$ = ... mol

(ii) The equation for the reaction taking place in the methyl orange titration is as follows.

$$HCO_3^- + H^+ \longrightarrow CO_2 + H_2O$$

Mean titre **B** is the volume needed to convert all the hydrogencarbonate ions present to carbon dioxide and water.

This hydrogencarbonate is from the original hydrogencarbonate **and** the converted carbonate, therefore

moles HCl in mean titre **B** = moles $NaHCO_3$ + moles Na_2CO_3

Use this information and the student's results to calculate the number of moles of hydrogencarbonate present in the original solution. [2]

$n(NaHCO_3)$ = ... mol

Examiner only

(iii) Use your answers to parts (i) and (ii) to show that the value of x in $Na_2CO_3.xNaHCO_3.yH_2O$ is 1. [1]

(iv) The relative formula mass of $Na_2CO_3.xNaHCO_3.yH_2O$ is 226. Calculate the value of y. [2]

y = ...

12

END OF PAPER

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