Surname	Centre Number	Candidate Number
First name(s)		2

GCE A LEVEL

A410U10-1

S25-A410U10-1

TUESDAY, 10 JUNE 2025 – MORNING

CHEMISTRY – A level component 1

Physical and Inorganic Chemistry

2 hours 30 minutes

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1. to 8.**	**15**	
Section B	**9.**	**21**	
	10.	**19**	
	11.	**19**	
	12.	**24**	
	13.	**22**	
	Total	**120**	

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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 120.

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 **Q9**(d) and **Q13**(c).

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SECTION A

Answer **all** questions.

1. State the colours observed in flame tests for compounds containing the following ions. [2]

Potassium ions .....

Lithium ions .....

2. Write the equation for the enthalpy of formation of ethanol. [2]

Include state symbols.

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3. Iron is used as a heterogeneous catalyst for the Haber process.

(a) State how catalysts act to increase the rate of a chemical reaction. [1]

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(b) State what is meant by the term heterogeneous in this context. [1]

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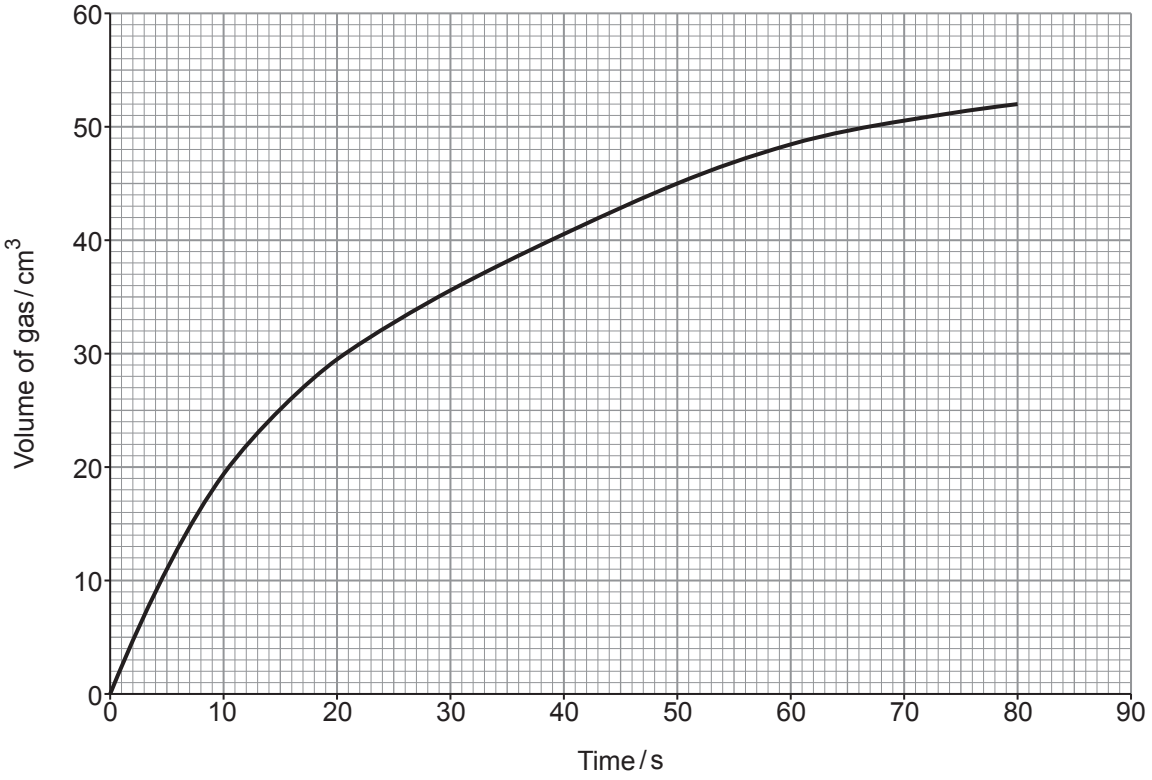
4. The graph below shows the volume of gas released during a chemical reaction.



Calculate the initial rate of the reaction. You **must** show your working. [2]

Initial rate = ... $cm^3 s^{-1}$

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5. Carbon dioxide is an acidic oxide and lead(II) oxide is an amphoteric oxide.

(a) Write an equation for a reaction that shows that carbon dioxide is an acidic oxide. [1]

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(b) State what is meant by the term amphoteric. [1]

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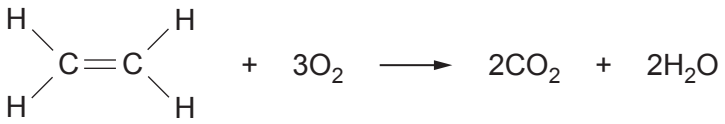
6. Use the average bond enthalpies listed to calculate the enthalpy change of the reaction shown. [2]



Bond	C — H	C — C	C = C	O = O	C = O	O — H
Average bond enthalpy / kJ mol^{-1}	412	348	612	496	743	463

Enthalpy change = ... kJ mol^{-1}

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7. State what is meant by the term dynamic equilibrium. [1]

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8. Neptunium-237 decays into protactinium-233 by radioactive decay.

(a) Identify the type of particle emitted in this process. [1]

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(b) State how this particle would be affected by an electric field. [1]

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SECTION B

Answer **all** questions.

9. Hydrogen is the most abundant element in the universe, making up approximately 74% of the universe by mass.

(a) The light emitted by stars such as our own sun contains a wide range of frequencies but when the spectrum is studied, dark lines are seen due to the absorption of certain specific frequencies of light by the hydrogen in the outer layers of the stars.

(i) Explain how the dark lines form and why they get closer together. [2]

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(ii) The first ionisation energy of hydrogen is 1312 kJ mol^{-1}. Calculate the wavelength of the convergence limit of the Lyman series in the atomic spectrum of hydrogen. [3]

Wavelength = ... nm

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(b) The first ionisation energies of some of the first 13 elements are listed in the table.

Element	H	He	Li	Be	B	C	N	O	F	Ne	Na	Mg	Al
First ionisation energy / kJ mol^{-1}	1312	2372		900	801	1087	1402	1314	1681	2081	496		578

(i) Suggest a value for the first ionisation energy of lithium. Give your reasoning. [2]

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(ii) Suggest a value for the first ionisation energy of magnesium. Explain your answer. [3]

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(c) Acids are substances that donate hydrogen ions.

(i) Give the difference between strong and weak acids. [1]

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(ii) A weak acid can be used to make a buffer solution.

A student takes a certain volume of ethanoic acid of initial concentration $0.200\,\text{mol}\,\text{dm}^{-3}$. They add the same volume of aqueous sodium hydroxide to form a buffer of pH 5.0.

Calculate the concentration of the aqueous sodium hydroxide. [4]

K_a of ethanoic acid = $1.78 \times 10^{-5}\,\text{mol}\,\text{dm}^{-3}$

Concentration of NaOH = ... $\text{mol}\,\text{dm}^{-3}$

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(d) Hydrogen bonding is one type of intermolecular force. Explain what is meant by hydrogen bonding and how it affects the properties of water.

You may include diagram(s) to support your answer. [6 QER]

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10. The following table contains a selection of *p*-block elements.

Group 4	Group 5	Group 6	Group 7
Si	P	S	Cl
Ge	As	Se	Br
Sn	Sb	Te	I
Pb	Bi	Po	At

(a) State why these elements are classed as part of the *p*-block. [1]

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(b) Use elements from the table above to answer parts (i)-(iii).

(i) Identify the most electronegative element in the table. [1]

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(ii) Give an element that forms an oxide of formula XO_2 and a hydride of formula H_2X.

..... [1]

(iii) Identify the element that gives purple fumes when the solid is heated. [1]

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(c) (i) Explain why silicon has the highest melting temperature of all these elements. [2]

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(ii) State why lead is the only Group 4 element that is most stable in the +2 oxidation state in its compounds. [1]

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(iii) Explain why addition of chlorine to a solution containing bromide ions causes a chemical reaction but addition of iodine to a solution containing bromide ions does not.

Include an equation for the reaction in your answer. [3]

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(d) Historically most of the tin and arsenic used in the United Kingdom was mined in Cornwall.

(i) The tin mined in Cornwall included the mineral cassiterite. Cassiterite is an oxide of tin that contains 78.8% tin by mass.

Find the formula of this oxide. You **must** show your working. [2]

Formula .....

(ii) Tin(II) compounds in solution oxidise slowly to form tin(IV).

The concentration of tin(II) ions remaining in solution can be found by titration against a solution containing iron(III) ions.

I. Write an equation for the reaction between Sn^{2+} ions and Fe^{3+} ions. [1]

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II. A standard solution containing 0.0210 mol dm^{-3} Fe^{3+} was used to titrate 25.0 cm^3 of a solution containing tin(II) ions. It needed 17.40 cm^3 of the Fe^{3+} solution for complete reaction.

Calculate the concentration of tin(II) ions in the solution. [3]

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

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(iii) Arsenic can form arsine, AsH_3. Use VSEPR theory to find the shape of this molecule.

Give your reasoning. [3]

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11. The chemistry of calcium is typical of the *s*-block elements.

(a) Calcium metal and calcium chloride can both conduct electricity under different conditions. State the conditions required and explain how these substances conduct electricity. [3]

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(b) Calcium hydroxide forms when calcium metal is added to water.

(i) Write the equation for the reaction between calcium and water. [1]

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(ii) Heating calcium hydroxide can cause it to decompose and form calcium oxide.

$$Ca(OH)_2(s) \longrightarrow CaO(s) + H_2O(g)$$

I. The entropy change for this reaction is $153\,J\,K^{-1}\,mol^{-1}$. Explain why the entropy change value is positive. [2]

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II. The minimum temperature required for this decomposition is 446°C. Find the enthalpy change of the reaction. [3]

Enthalpy change = ... $kJ\,mol^{-1}$

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(c) One mineral that contains calcium is gaylussite, $Ca_aM_b(CO_3)_c.dH_2O$. Metal M is another *s*-block element.

Strong heating of 2.50×10^{-2} mol of solid gaylussite decomposes the mineral in two stages, with the solid losing 30.4% of its initial mass in the first stage and then 29.7% of the initial mass in the second stage.

The gases released are passed through a U-tube surrounded by ice and 2.25 g of a colourless liquid condenses during the first stage of decomposition. The remaining gases are bubbled through limewater which turns milky during the second stage.

(i) Find the value of d. [2]

d = ...

(ii) Find the relative formula mass, M_r, of gaylussite. [2]

M_r = ...

(iii) Find the value of c. [3]

c = ...

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(iv) Use your answers to parts (i), (ii) and (iii) to deduce the identity of metal M and hence write the formula of gaylussite. [3]

M is .....

Formula of gaylussite .....

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12. Chromium and copper are both elements in the first row of the *d*-block.

(a) Write the electronic structure of a chromium atom. [1]

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(b) Acidified potassium dichromate solution is orange and changes colour when it reacts with other substances.

(i) State and explain the colour change that occurs when aqueous iron(II) sulfate is added to acidified potassium dichromate solution. [2]

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(ii) State and explain the colour change that occurs when excess aqueous sodium hydroxide is added to acidified potassium dichromate solution. [2]

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(c) Copper(II) ions in aqueous solution form a pale blue solution.

(i) Explain why the solution is pale blue. [3]

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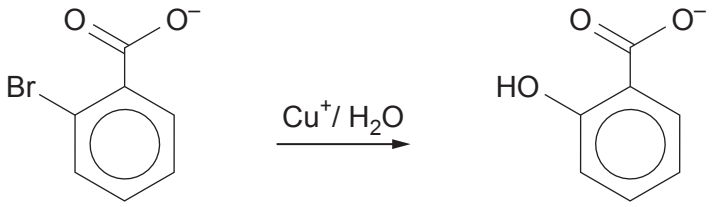
(ii) Addition of concentrated hydrochloric acid causes the solution to turn green.

Draw the structure of the copper-containing ion present in the solution. [1]

(d) Copper(I) compounds are used as catalysts in the Ullman reaction which converts 2-bromobenzoate into 2-hydroxybenzoate.



(i) Suggest why the reaction must be performed in the absence of air. [1]

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(ii) Suitable ligands must be chosen for the reaction to prevent the copper(I) ions precipitating as $Cu_2O(s)$ or undergoing disproportionation.

State what is meant by disproportionation. [1]

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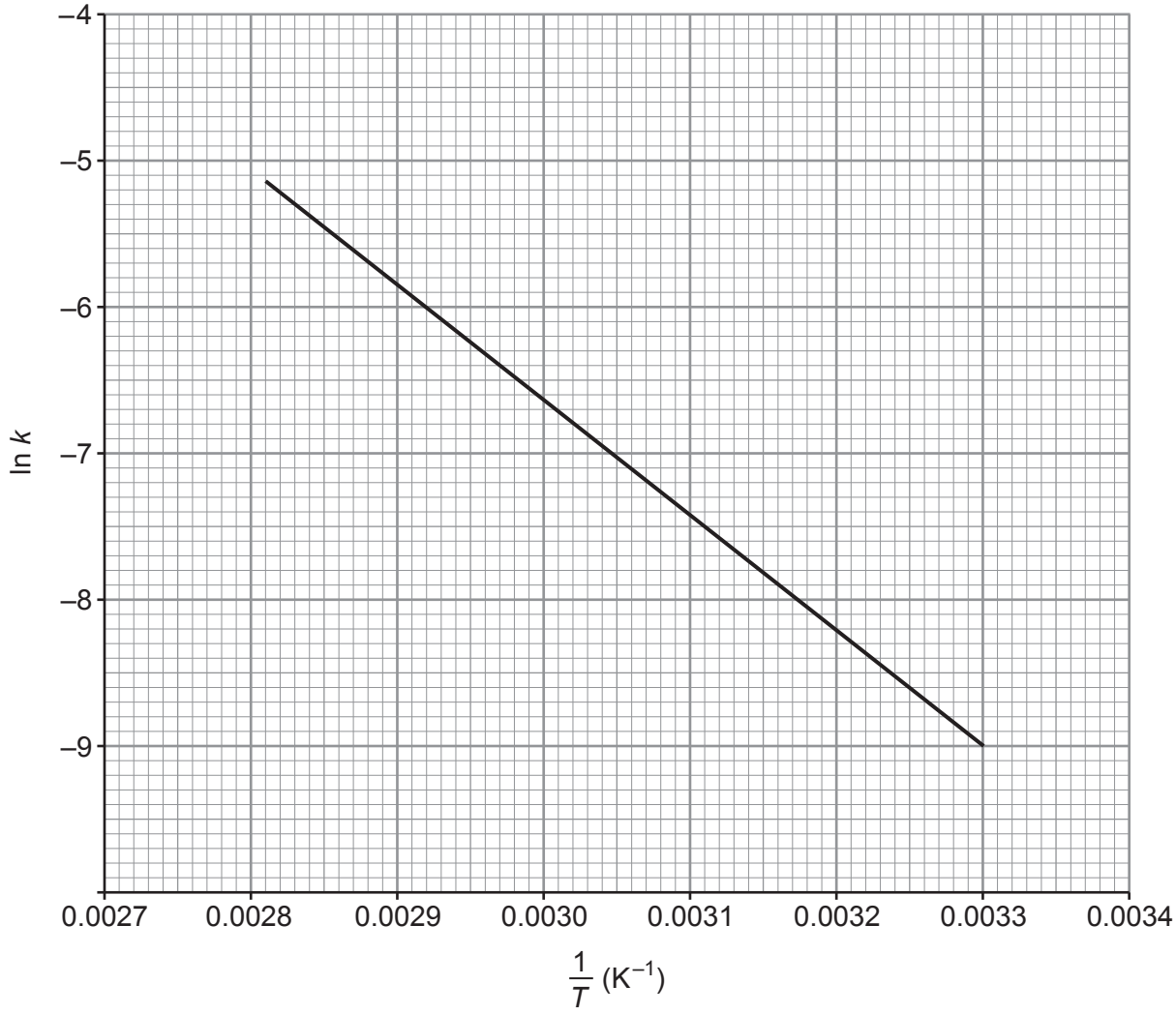
(iii) The reaction is first order overall and the rate depends on the concentration of the copper complex only.

The rate constant for the reaction was found at four different temperatures with the initial concentration of the 2-bromobenzoic acid being $1.0 \times 10^{-3}\,\text{mol}\,\text{dm}^{-3}$ and the copper complex having a concentration of $2.5 \times 10^{-5}\,\text{mol}\,\text{dm}^{-3}$.

A plot of $\ln k$ against $\frac{1}{T}$ is shown below.



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I. Give the unit of the rate constant for this reaction. [1]

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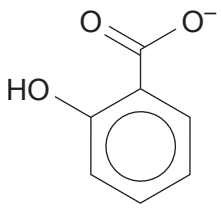
II. Calculate the rate of the reaction at a temperature of 50°C. [4]

Rate = ... $mol\,dm^{-3}\,s^{-1}$

III. Calculate the activation energy of the reaction. [3]

Activation energy = ... $kJ\,mol^{-1}$

(iv) Under the conditions of the reaction, the ion below is formed. State what information this provides regarding the relative K_a values of the protons in 2-hydroxybenzoic acid. [1]



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(v) Copper(I) complexes such as $[Cu(CN)_2]^-$ can act as reducing agents for other metal ions.

	Standard electrode potential, E^θ/V
$Pr^{4+} + e^- \rightleftharpoons Pr^{3+}$	+3.21
$Mn^{3+} + e^- \rightleftharpoons Mn^{2+}$	+1.51
$MnO_2 + 4H^+ + e^- \rightleftharpoons Mn^{3+} + 2H_2O$	+1.23
$Cu^{2+} + 2CN^- + e^- \rightleftharpoons [Cu(CN)_2]^-$	+1.12
$VO^{2+} + 2H^+ + e^- \rightleftharpoons V^{3+} + H_2O$	+0.34
$V^{3+} + e^- \rightleftharpoons V^{2+}$	–0.26
$Pr^{3+} + e^- \rightleftharpoons Pr^{2+}$	–3.11

When $[Cu(CN)_2]^-$ is added to metal compounds in the +4 oxidation state the metal can be reduced to a lower oxidation state.

Identify which of the metals, manganese, vanadium and praseodymium in their +4 oxidation state, will form ions in their +3 oxidation state in the final product when excess $[Cu(CN)_2]^-$ is added. Explain your reasoning. [4]

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13. A saturated solution of iodine in water has a concentration of $1.33 \times 10^{-3}\,\text{mol}\,\text{dm}^{-3}$ at 298 K.

(a) Addition of iodide ions causes the following equilibrium to be established.

$$I_2(aq) + I^-(aq) \rightleftharpoons I_3^-(aq)$$

A solid sample of 0.100 g of potassium iodide is added to $1.00\,\text{dm}^3$ of a saturated solution of $I_2(aq)$ at 298 K. At equilibrium the solution contains $I_3^-(aq)$ of concentration $2.62 \times 10^{-4}\,\text{mol}\,\text{dm}^{-3}$.

Calculate the value of the equilibrium constant, K_c. [4]

K_c = ... $\text{mol}^{-1}\,\text{dm}^3$

(b) Addition of bromide ions to a saturated solution of iodine causes interhalogen ions to form, $Br_nI_m^{x-}$.

(i) One interhalogen ion is crystallised as a potassium salt and the M_r of this compound is found to be 373. Identify the formula of this interhalogen salt. [2]

Formula .....

(ii) The interhalogen ions have a negative charge so it is difficult to use a traditional mass spectrometer to measure their mass. Suggest **one** adaptation to a mass spectrometer so that it can measure the mass of these interhalogen ions. Give a reason for your suggestion. [1]

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(iii) The spectrum of the interhalogen ion Br_2I^- contains three peaks with masses of 285, 287 and 289. Assume that all the iodine atoms present are iodine-127.

I. Show that the bromine isotopes present in these ions are bromine-79 and bromine-81. [2]

II. Bromine-79 and bromine-81 are the only stable isotopes of bromine and the relative atomic mass (A_r) of bromine is 79.98.

Calculate the percentage of each isotope present in bromine. [3]

Percentage bromine-79 = ... %

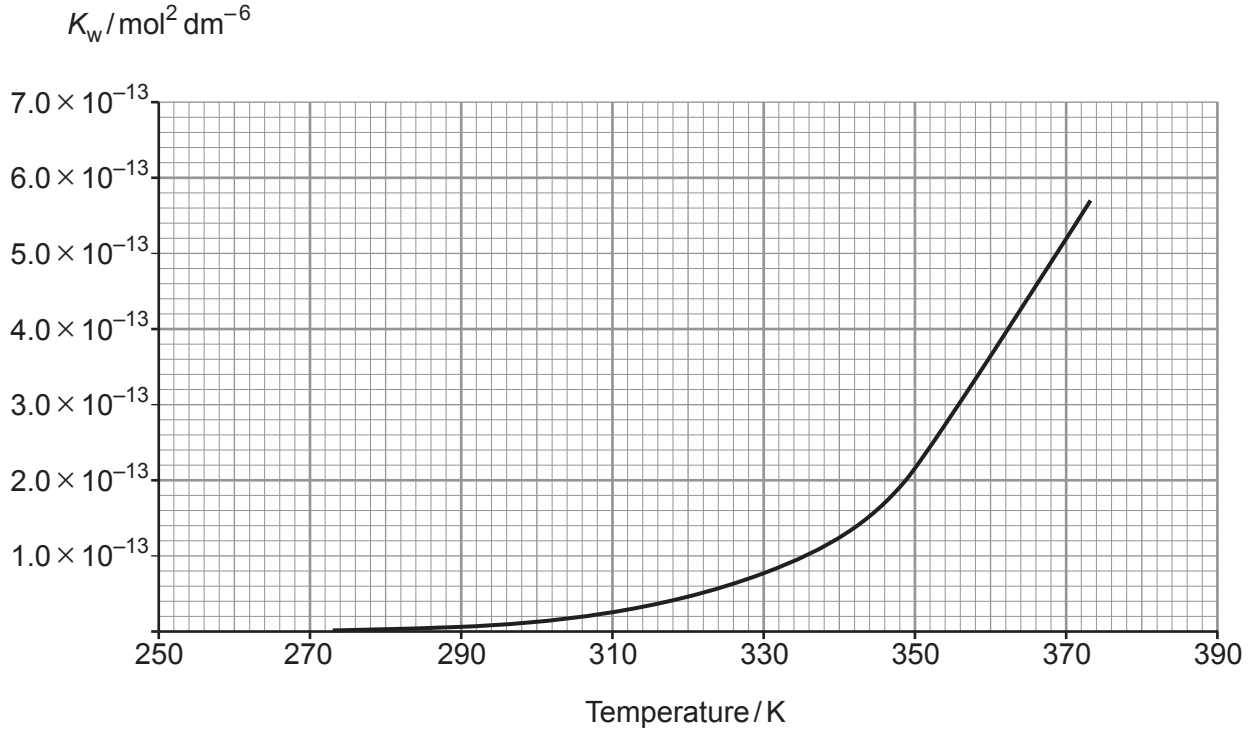
Percentage bromine-81 = ... %

(iv) The interhalogen compound ClF_3 is a gas at a particular temperature. The density of the gas is found to be $3.60\,g\,dm^{-3}$ at a pressure of 1 atm.

Calculate the temperature. [4]

Temperature = ... K

(c) The ionic product of water, K_w, varies with temperature as shown in the graph below.



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Discuss the ionic product of water and its temperature dependance.

Your answer should include:

- the meaning of K_w
- the information that can be obtained from the temperature dependance of K_w
- how K_w is used to find the pH of a strong alkali, and how the pH of a strong alkali changes with temperature

[6 QER]

END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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