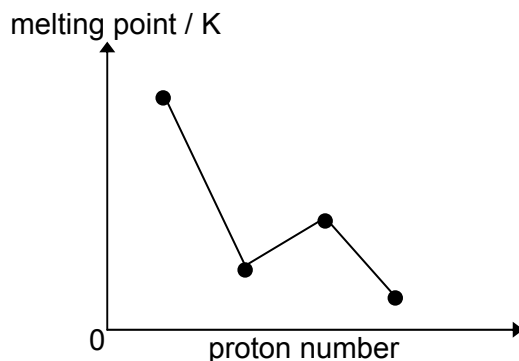


Section B

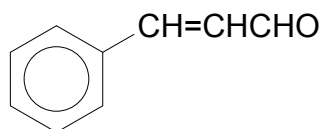
Answer **two** questions from this section on separate writing paper.

- 5 (a) The diagram represents the melting points of four consecutive elements in the third period of the Periodic Table.



- (i) Identify the elements giving reasons for your choice.
- (ii) Sketch a graph to show the third ionization energies of these 4 elements and give reasons for any trends shown in the graph.
- (b) The main component of cinnamon oil is cinnamaldehyde.

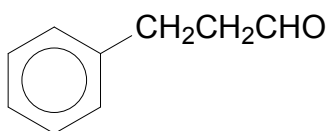
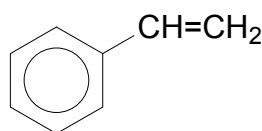
[6]



- (i) State suitable reagents and conditions required to reduce only the carbonyl functional group of cinnamaldehyde.

Draw the full structural formula of the organic product.

- (ii) Suggest simple test-tube reactions (one in each case) that could be used to distinguish cinnamaldehyde from compounds **A** and **B** below.

**A****B**

[Equations are not required.]

[6]

- (c) Chlorofluorocarbons (CFCs) are used in refrigerants, aerosol propellants and fire extinguishers.

The table below shows the boiling points of some CFCs and their derivatives.

Compound	Boiling point / °C
CBrF_3	149
CHF_2Cl	41
CF_2Cl_2	-30

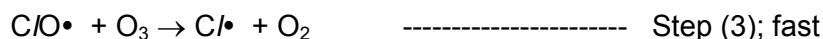
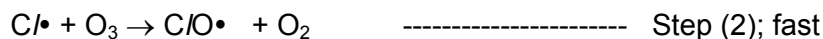
Name one physical property of CFCs that makes them suitable for their uses.

[1]

- (d) Greenhouse gases are those that can absorb and emit infrared radiation but not radiation in or near the visible spectrum. Water, carbon dioxide and ozone are some of the more abundant greenhouse gases.

(i) Draw the dot-and-cross diagram of the CO_2 and H_2O molecules. State their bond angles and molecular shapes.

(ii) The 'hole' in the ozone layer over the Antarctic has been attributed to the reaction between CFCs and ozone in the stratosphere *via* the following:



where $\text{CF}_2\text{Cl}\cdot$, $\text{Cl}\cdot$, $\text{ClO}\cdot$ are radicals which contain an unpaired electron.

Briefly explain why fluorine radicals, $\text{F}\cdot$, are not formed in step (1).

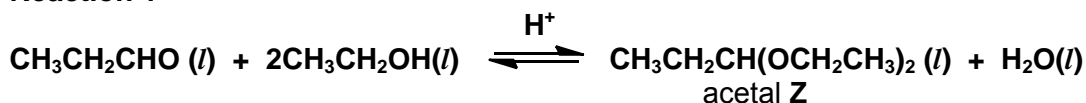
- (iii) State one effect of ozone depletion and a measure that has been taken to reduce ozone depletion.

[7]

[Total: 20]

- 6 Acetals are compounds formed when aldehydes or ketones are reacted with an alcohol and an acid catalyst. For example, propanal and ethanol was reacted in an inert solvent dioxin with an acid catalyst to produce acetal **Z** as shown in **reaction 1** below.

Reaction 1



- (a) When the initial rate of the above **reaction 1** was measured at various starting concentrations of the three reactants, the following results were obtained.

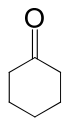
Experiment Number	[CH ₃ CH ₂ CHO]/ mol dm ⁻³	[CH ₃ CH ₂ OH]/ mol dm ⁻³	[H ⁺]/ mol dm ⁻³	Rate/ mol dm ⁻³ s ⁻¹
1	0.20	0.10	0.050	0.100
2	0.25	0.10	0.050	0.125
3	0.25	0.16	0.050	0.200
4	0.20	0.16	0.100	0.320

- (i) Use the data in the table to determine the order with respect to each reactant.
- (ii) Use your results from (a)(i) to write the rate equation for the reaction.
- (iii) Calculate the rate constant and state its units.
- (iv) Calculate the rate of the reaction for a mixture in which the starting concentrations of all three reactants are 0.20 mol dm⁻³. [7]
- (b) The concentration of the acetal **Z** was measured when experiment 1 in (a) was allowed to reach equilibrium. The result is included in the following table.

	[CH ₃ CH ₂ CHO] / mol dm ⁻³	[CH ₃ CH ₂ OH] / mol dm ⁻³	[H ⁺] /mol dm ⁻³	[acetal Z] /mol dm ⁻³	[H ₂ O] /mol dm ⁻³
At start	0.20	0.10	0.05	0.00	0.00
At equilibrium				0.025	

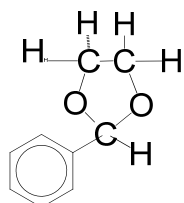
- (i) Given that the equilibrium concentration of acetal **Z** is 0.025 mol dm⁻³, calculate the equilibrium concentrations of the reactants, catalyst and product.
- (ii) Write the expression for the equilibrium constant for this reaction, K_c, stating its units.
- (iii) Use the equilibrium concentration values to calculate the value of K_c.
- (iv) Explain, with the aid of the Maxwell Boltzmann distribution curve, how the acid catalyst can speed up the reaction between propanal and ethanol as shown in **reaction 1**. [8]

- (c) (i) Give the structural formula of the acetal formed when cyclohexanone,



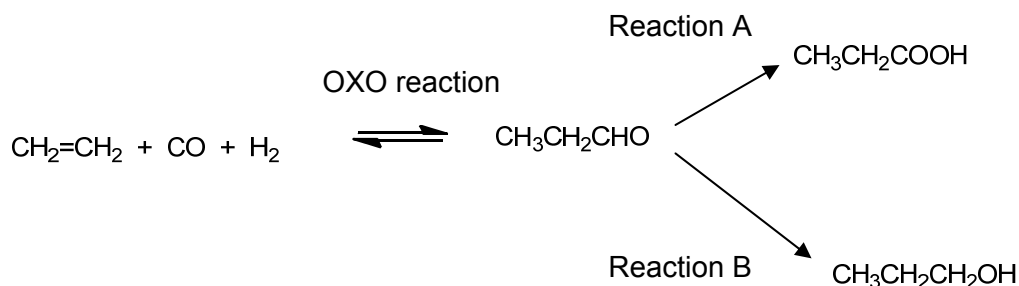
, is reacted with methanol, CH_3OH , in the presence of an acid catalyst.

- (ii) Predict the aldehyde and alcohol used to prepare ethylene acetal as shown below.



ethylene acetal

- (iii) Propanal used in **reaction 1** can be prepared by the “OXO” reaction. This reaction is an important homogeneously catalyzed industrial process for the production of aldehydes from alkenes. This chemical reaction entails the addition of a CHO group and a hydrogen atom to a carbon-carbon double bond. Propanal can also be used to prepare other useful products as shown below.



State the reagents and conditions needed for

- Reaction A
- Reaction B

[5]

[Total: 20]

7 Elements **X**, **Y** and **Z** are consecutive elements in period 3 of the Periodic Table.

It is known that the element **X** and **Y** both form chlorides which hydrolyse in water to form acidic solutions and oxides which have high melting point.

- (a) At room temperature, the chloride of **X** exists as a yellow-white solid and has the empirical formula of XC_{l_3} and a relative molecular mass of 267.

Suggest the molecular formula of the solid and draw a dot-and-cross diagram to illustrate its bonding. [2]

- (b) The chloride of **X** can react with water in two separate ways.

- 1) When a few drops of water are added to the chloride of **X**, a violent reaction is observed. Steamy white fumes are produced and a white solid, which is insoluble in water, is formed.
- 2) When the chloride of **X** is added to excess amount of water, a weakly acidic solution is formed instead.

Write balanced equations, including state symbols, for the above two reactions and briefly explain the result in the second reaction. [3]

- (c) Deduce and explain if the melting point of the chloride of **X** is higher or lower than that of the chloride of **Y**. [2]

- (d) The oxides of Period 3 elements can dissolve in or react with water to form solutions of different pH.

- (i) Considering only the higher oxides of sodium to sulfur, sketch a graph to show the variation in pH of the solutions produced. Label your axes clearly.

- (ii) Briefly explain the general shape of your graph, relating to the nature of the oxides. [5]

- (e) Samples of the oxide of **X** and the oxide of **Y** are accidentally mixed up. Describe a simple chemical test to distinguish these two samples and state the observation. Write a balanced equation for the reaction that occurs. [3]

- (f) The higher chloride of **Z** and the oxide of **X** are common chemical reagents that are widely used in organic reactions. The following reactions show how they are used in the chemical conversion of organic compounds.

A neutral compound **A**, $\text{C}_7\text{H}_{14}\text{O}_3$, is heated in dilute sulfuric acid to form compounds **B**, $\text{C}_3\text{H}_6\text{O}_3$ and **C**, $\text{C}_4\text{H}_{10}\text{O}$ respectively. Compound **B** can react with 2 moles of the higher chloride of **Z** to give compound **D**. Compound **B** can also react with the oxide of **X** at 350°C to form compound **E**. It is known that both compounds **B** and **C** give positive results with alkaline aqueous iodine.

Identify compound **A** to **E**. Explanation is not required. [5]

[Total: 20]