Write your name here

Surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Paper 2: Advanced Organic and Physical Chemistry

Sample Assessment Materials for first teaching September 2015

Time: 1 hour 45 minutes

Paper Reference **9CH0/02**

You must have:
Data Booklet
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **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 90.
- 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 may use a scientific calculator.
- For questions marked with an *****, marks will be awarded for your ability to structure your answer logically showing the points that you make are related or follow on from each other where appropriate.
- A Periodic Table is printed on the back cover of this paper.

Advice

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

Turn over ▶

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Answer ALL questions.

Write your answers in the spaces provided.

Some questions must be answered with a cross in a box ☒.
If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 This question is about some hydrocarbons.

(a) (i) Which isomeric alkane has the lowest boiling temperature?

(1)

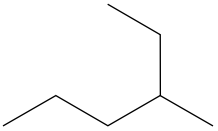
☒ **A** 2,2-dimethylbutane

☒ **B** hexane

☒ **C** 3-methylpentane

☒ **D** 2-methylpentane

(ii) What is the name of this alkane?



(1)

☒ **A** 4-ethylpentane

☒ **B** 2-ethylpentane

☒ **C** 4-methylhexane

☒ **D** 3-methylhexane

(b) Describe how the orbitals from carbon atoms interact to form the bonds in a benzene ring. You may include a labelled diagram to support your answer.

(3)

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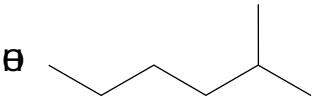
(Total for Question 1 = 5 marks)

2 The skeletal formulae of four compounds are shown.

A



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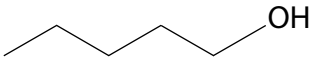

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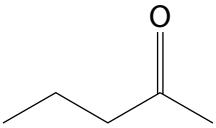

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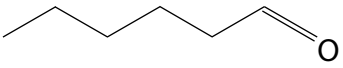

(a) Which compound has the molecular formula $C_6H_{14}O$?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(b) Which compound forms a pale yellow precipitate when reacted with iodine and sodium hydroxide solution?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(c) Which compound forms a silver mirror when reacted with Tollens' reagent?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 2 = 3 marks)

3 This question is about amines.

(a) Amines can behave as bases.

What is meant by the term base?

(1)

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(b) Which of these compounds has the highest pH when dissolved in water to form solutions of the same concentration?

(1)

- ☒ **A** NH_3
- ☒ **B** CH_3NH_2
- ☒ **C** $C_6H_5NH_2$
- ☒ **D** NH_4Cl

(c) A student wrote a statement about the mechanism of the reaction between a primary chloroalkane and an amine.

> The amine acts as a nucleophile due to its unpaired electron. It attacks the slightly positive carbon in the chloroalkane, forming an intermediate. The carbon is slightly positive as it is attached to an electropositive chlorine atom. The intermediate then loses a proton and a chloride ion, forming the product, an N-substituted amide.

Identify and correct **two** of the errors in the statement.

(2)

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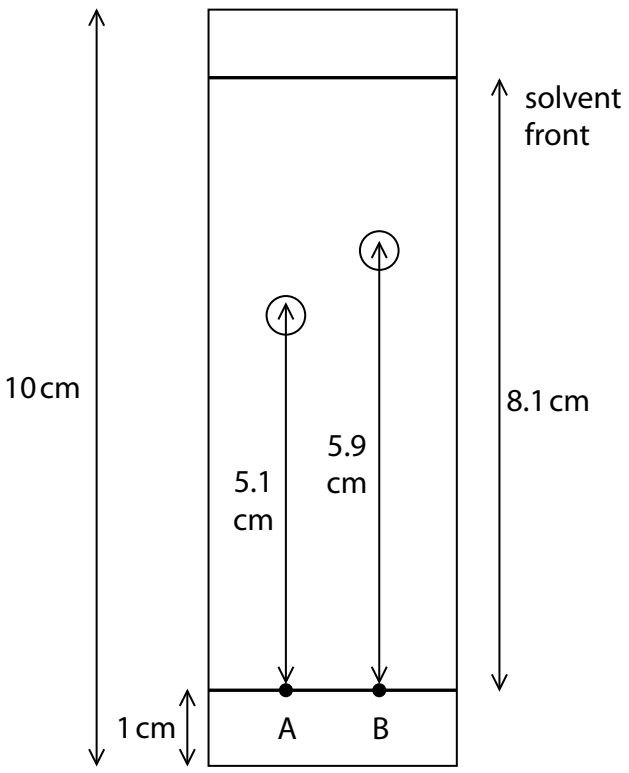
(Total for Question 3 = 4 marks)

4 This question is about the properties of amino acids and other organic compounds.

(a) A chromatogram of two amino acids, **A** and **B**, is shown.



The R_f value of amino acid A is

(1)

- ☒ **A** 0.51
- ☒ **B** 0.56
- ☒ **C** 0.63
- ☒ **D** 0.67

(b) Amino acid **B** has the structure $H_2NCH(CH_2CH(CH_3)_2)COOH$

Predict the pH of the solution formed when it dissolves in water and justify your answer.

(2)

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(c) Some data about different organic compounds is shown in the table.

Compound	Relative molecular mass	Melting temperature / °C
glycine (an amino acid)	75	233
butan-1-ol	74	−90
pentane	72	−130

Use information from the table to justify the types of intermolecular forces in each of these compounds.

(4)

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(Total for Question 4 = 7 marks)

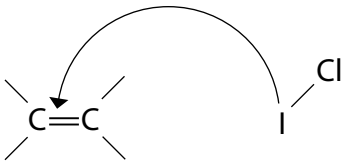
5 This question is about the chemistry of iodine compounds and hydrocarbons.

(a) Iodine monochloride (ICl) reacts with unsaturated compounds such as sunflower oil.

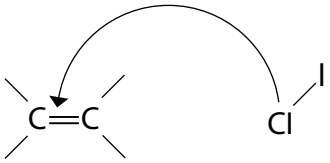
(i) Which diagram shows the first step in the mechanism of the reaction between iodine monochloride and an unsaturated compound?

(1)

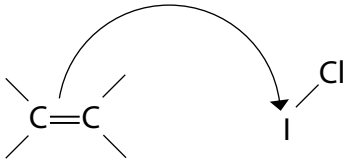
☒ **A**



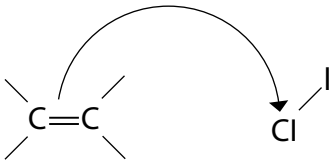
☒ **B**



☒ **C**



☒ **D**



(i) What is the name and type of the mechanism in the overall reaction?

(1)

- ☒ **A** electrophilic substitution
- ☒ **B** nucleophilic substitution
- ☒ **C** electrophilic addition
- ☒ **D** nucleophilic addition

(b) The number of grams of iodine from iodine monochloride that reacts with 100 g of an oil or fat is known as the iodine value and is used to compare levels of unsaturation in different oils and fats.

An excess of iodine monochloride, 11.0 g, was mixed with 6.40 g of sunflower oil. The remaining unreacted iodine monochloride was treated with excess potassium iodide to liberate iodine.

$$ICl + KI \rightarrow KCl + I_2$$

The liberated iodine was titrated with sodium thiosulfate solution of concentration 0.500 mol dm^{-3}. 21.20 cm^3 of this solution was required to completely react with the liberated iodine.

$$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6$$

(i) Calculate the amount, in mol, of sodium thiosulfate that reacted with the liberated iodine and hence calculate the amount (in mol) of liberated iodine.

(2)

(i) Use your answer to (i) and the initial mass of iodine monochloride, 11.0 g, to calculate the iodine value of the oil.

(5)

(c) Sunflower oil can be hydrogenated to form solid fats such as margarine.
What is the **most** appropriate catalyst for this reaction?

(1)

- ☒ **A** nickel
- ☒ **B** iron
- ☒ **C** rhodium
- ☒ **D** vanadium(V) oxide

(Total for Question 5 = 10 marks)

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6 This question is about the kinetics of chemical reactions.

(a) The rate equation for the reaction between hydrogen and nitrogen monoxide is:

$$\text{rate} = k[H_2][NO]^2$$

By what factor does the rate increase when the concentration of hydrogen is tripled and that of nitrogen monoxide is doubled?

(1)

- ☒ **A** 5
- ☒ **B** 6
- ☒ **C** 12
- ☒ **D** 18

(b) The 'initial rates' method is used to investigate the orders of reaction with respect to reactants **A**, **B** and **C**. The table shows the results obtained.

Run	Initial concentration / mol dm^{-3}			Initial rate / mol dm^{-3} s^{-1}
	A	B	C	
1	0.32	0.080	0.16	2.4×10^{-3}
2	0.64	0.080	0.16	4.8×10^{-3}
3	0.32	0.16	0.16	9.6×10^{-3}
4	0.64	0.32	0.48	0.23

(i) Deduce the orders with respect to **A** and **B**.

(2)

A .....

B .....

(ii) Deduce the order with respect to **C** and justify your answer.

(2)

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(iii) Give the rate equation for the reaction.

(1)

(iv) Calculate the rate constant, *k*, to an appropriate number of significant figures.
Give units for your answer.

(3)

(c) A different reaction, between iodine and propanone, in the presence of hydrogen ions, has the rate equation:

$$\text{rate} = k[CH_3COCH_3][H^+]$$

(i) Give the overall order of the reaction.

(1)

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(ii) Explain, in terms of collision theory, why increasing the concentration of propanone changes the rate of reaction.

(2)

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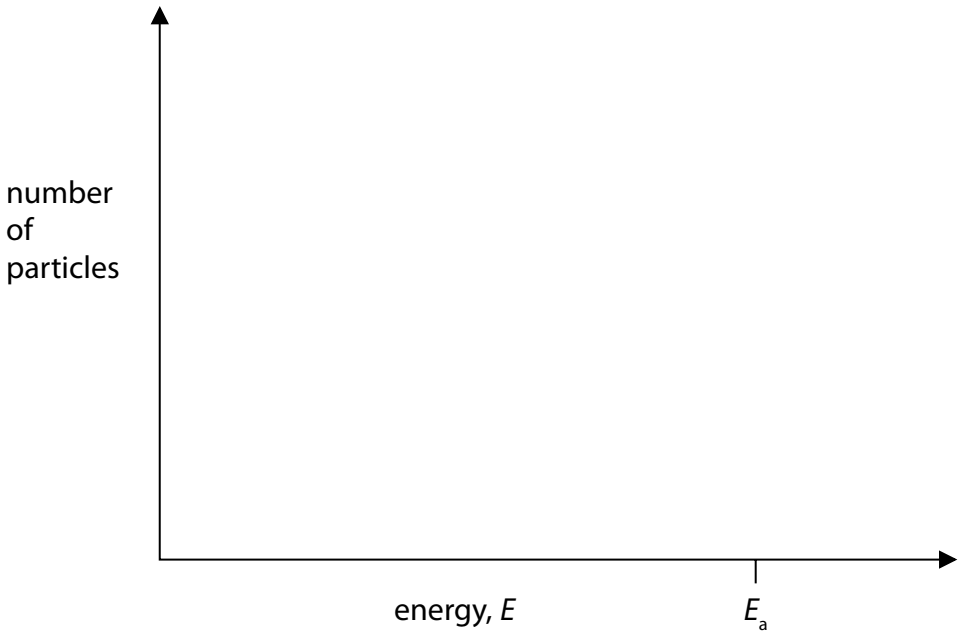
(d) Catalysts are sometimes used in reactions.

(i) Explain how a catalyst affects the rate of a reaction.

(3)

(ii) Draw and label lines on the axes to show how an increase in temperature affects the number of particles with $E > E_a$.

(2)



(Total for Question 6 = 17 marks)

7 The compound 2-phenylethyl propanoate is a synthetic oil used in some fragrances due to its rose-like aroma.

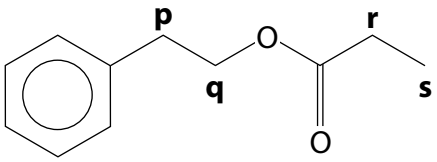
(a) Combustion analysis of 1.56 g of 2-phenylethyl propanoate, in a laboratory, produced 4.26 g of $CO_2(g)$ and 1.10 g of $H_2O(l)$

Show that the data is consistent with the molecular formula of 2-phenylethyl propanoate, $C_{11}H_{14}O_2$.

(4)

(b) Nuclear magnetic resonance (NMR) spectroscopy can be used to determine structural formulae.

An incomplete ^{1}H NMR spectrum for 2-phenylethyl propanoate shows a peak for the hydrogen atoms attached to the benzene ring.

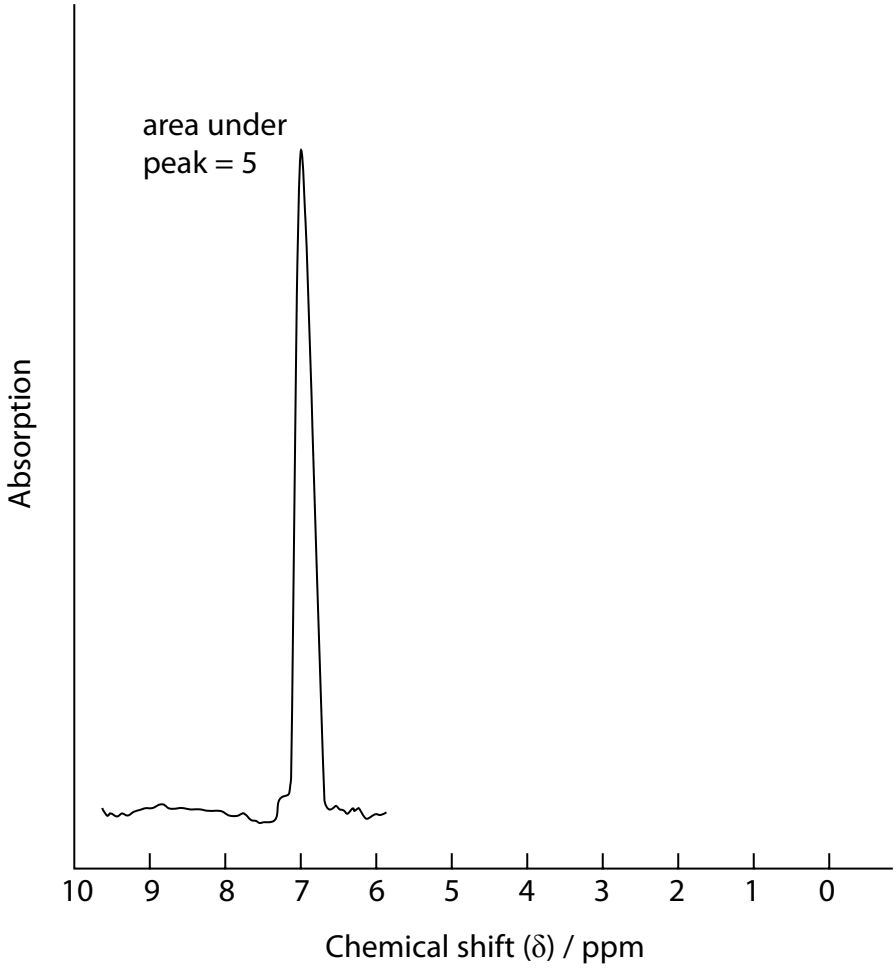


Complete the spectrum for the protons attached to the carbon atoms **p**, **q**, **r** and **s**, giving the relative areas under each peak.

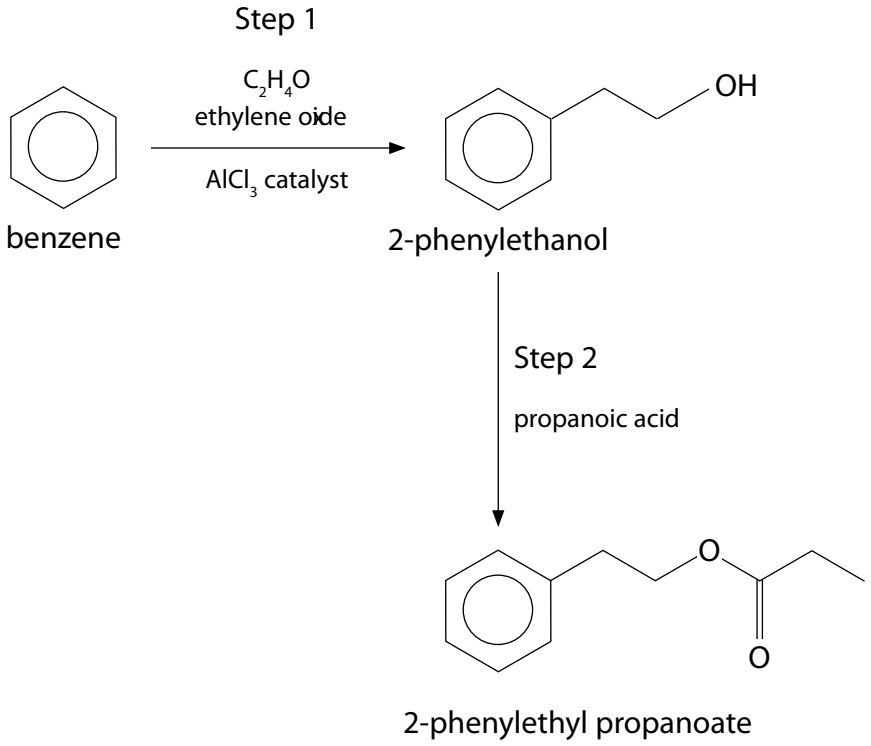
You should use the Data Booklet. Your spectrum does not have to be to scale.

(6)

Predicted spectrum:



(c) A possible synthetic route to prepare 2-phenylethyl propanoate is:



(i) The attacking species in Step 1 can be represented as $^{+}CH_2CH_2OAlCl_3^{-}$

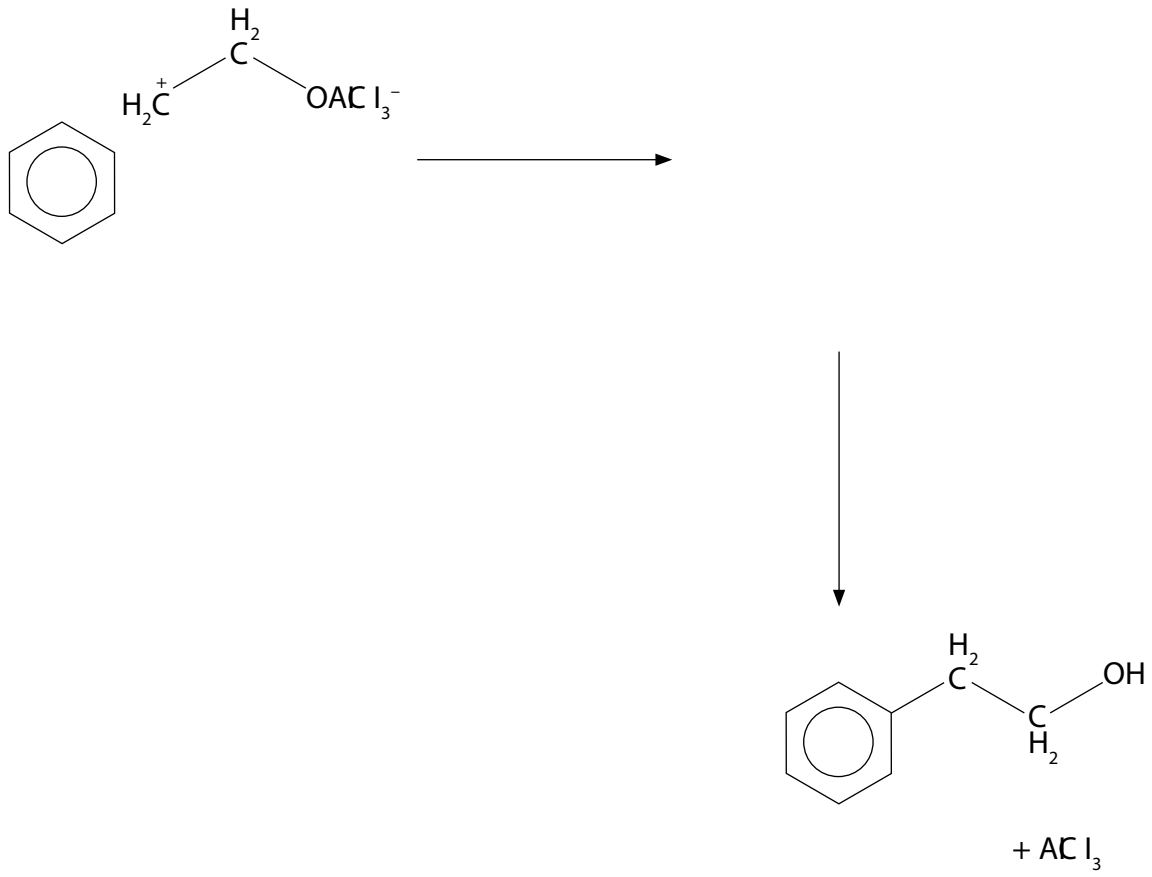
What is the mechanism in this step?

(1)

- ☒ **A** electrophilic substitution
- ☒ **B** nucleophilic substitution
- ☒ **C** electrophilic addition
- ☒ **D** nucleophilic addition

(i) Complete the diagram, including curly arrows, to show the mechanism for the reaction to form 2-phenylethanol.

(4)



(ii) In the synthetic route, what type of reaction is Step 2?

(1)

- ☒ **A** hydrolysis
- ☒ **B** esterification
- ☒ **C** neutralisation
- ☒ **D** hydrogenation

(v) Name a suitable catalyst for Step 2.

(1)

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(Total for Question 7 = 17 marks)

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8 Propanoic acid can be synthesised from propene, a by-product of the petrochemical industry.

(a) Complete the equation to show the formation of propene and one other hydrocarbon.

$$C_{10}H_{22} \rightarrow C_3H_6 + \text{.....}$$

(1)

(b) Propanoic acid can be synthesised from propene in 3 steps. A student proposed the following synthesis:

Step 1: propene $\rightarrow$ 1-bromopropane

Step 2: 1-bromopropane $\rightarrow$ **X**

Step 3: **X** $\rightarrow$ propanoic acid

(i) Identify **X** and give the conditions needed to carry out Step 2 and Step 3 in this synthesis.

(4)

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(ii) Explain, by considering the mechanism of the reaction, why the student's choice of reaction for Step 1 will lead to a low overall yield.

(2)

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(c) Propene is used in the manufacture of polymers.

(i) Write an equation to show the formation of poly(propene) from propene.

(2)

(ii) Describe how the chemical reaction to form the polymer nylon differs from the chemical reaction to form poly(propene)

(2)

(iii) Give **two** ways in which chemists contribute to a more sustainable use of such materials as poly(propene) and nylon.

(2)

(Total for Question 8 = 13 marks)

9 The table shows the formulae of three different halogenoalkanes and the optical activity of the products of their reaction with hydroxide ions in aqueous solution.

Reaction	Halogenoalkane reacting with hydroxide ions	Optical activity of product mixture
1	CH_3Cl	none
2	$CH_3CBrHCH_2CH_3$	significant
3	$CH_3CH_2CH_2CBr(CH_3)CH_2CH_3$	no significant activity

(a) Draw the mechanism for reaction **1**.

(4)

(b) The halogenoalkane in reaction **2** is 2-bromobutane.

(i) Name the halogenoalkane in reaction **3**.

(1)

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(f) (i) Both halogenoalkanes used in reaction **2** and reaction **3** were a single optical isomer.

Explain the optical activity of the product mixture for reaction **2** and reaction **3**, in terms of the reaction mechanism.

(6)

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(c) Compounds containing the alkene functional group can show stereoisomerism.

(i) Draw the **two** structural isomers for an alkene that shows stereoisomerism.

(1)

(i) Explain why stereoisomerism occurs in alkenes.

(2)

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(Total for Question 9 = 14 marks)

TOTAL FOR PAPER = 90 MARKS

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