4 Acyl chlorides and acid anhydrides are important compounds in organic synthesis.

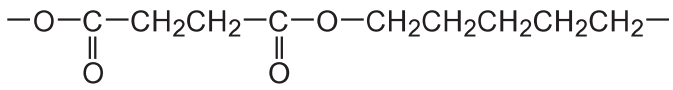
4 (a) Outline a mechanism for the reaction of CH_3CH_2COCl with CH_3OH and name the organic product formed.

Mechanism

Name of organic product .....

(5 marks)

4 (b) A polyester was produced by reacting a diol with a diacyl chloride. The repeating unit of the polymer is shown below.



4 (b) (i) Name the diol used.

.....

(1 mark)

4 (b) (ii) Draw the displayed formula of the diacyl chloride used.

(1 mark)

4 (b) (iii) A shirt was made from this polyester. A student wearing the shirt accidentally splashed aqueous sodium hydroxide on a sleeve. Holes later appeared in the sleeve where the sodium hydroxide had been.

Name the type of reaction that occurred between the polyester and the aqueous sodium hydroxide. Explain why the aqueous sodium hydroxide reacted with the polyester.

Type of reaction .....

Explanation .....

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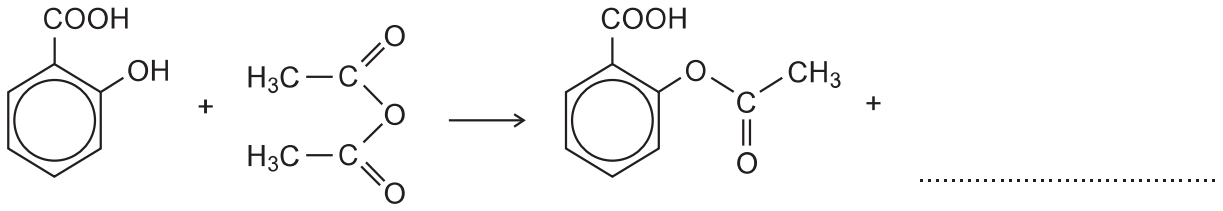
(3 marks)

4 (c) (i) Complete the following equation for the preparation of aspirin using ethanoic anhydride by writing the structural formula of the missing product.



aspirin

(1 mark)

4 (c) (ii) Suggest a name for the mechanism for the reaction in part **(c) (i)**.

.....

(1 mark)

4 (c) (iii) Give **two** industrial advantages, other than cost, of using ethanoic anhydride rather than ethanoyl chloride in the production of aspirin.

Advantage 1 .....

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.....

Advantage 2 .....

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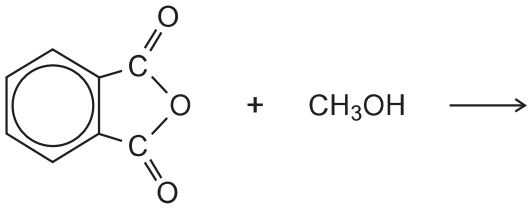
(2 marks)

Question 4 continues on the next page

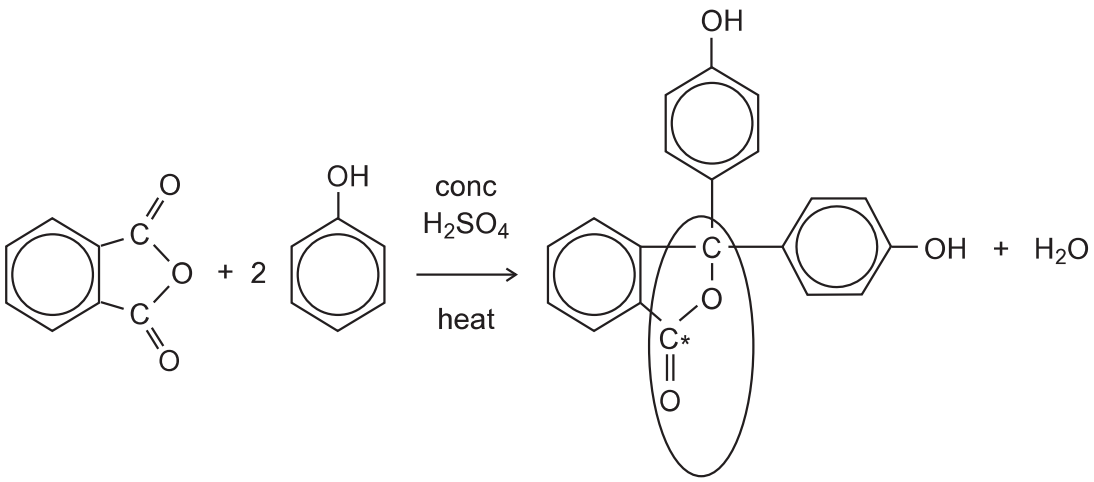
Turn over ▶

4 (d) Complete the following equation for the reaction of one molecule of benzene-1,2-dicarboxylic anhydride (phthalic anhydride) with one molecule of methanol by drawing the structural formula of the single product.



(1 mark)

4 (e) The indicator phenolphthalein is synthesised by reacting phthalic anhydride with phenol as shown in the following equation.



phenol phenolphthalein

4 (e) (i) Name the functional group ringed in the structure of phenolphthalein.

.....

(1 mark)

4 (e) (ii) Deduce the number of peaks in the ^{13}C n.m.r. spectrum of phenolphthalein.

.....

(1 mark)

4 (e) (iii) One of the carbon atoms in the structure of phenolphthalein shown above is labelled with an asterisk (*).
Use **Table 3** on the Data Sheet to suggest a range of δ values for the peak due to this carbon atom in the ^{13}C n.m.r. spectrum of phenolphthalein.

.....

(1 mark)

Section B

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

10 The reactions of molecules containing the chlorine atom are often affected by other functional groups in the molecule.

Consider the reaction of CH_3CH_2COCl and of $CH_3CH_2CH_2Cl$ with ammonia.

10 (a) For the reaction of CH_3CH_2COCl with ammonia, name and outline the mechanism and name the organic product.

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(6 marks)

(Extra space) .....

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10 (b) For the reaction of $CH_3CH_2CH_2Cl$ with an **excess** of ammonia, name and outline the mechanism and name the organic product.

(6 marks)

(Extra space) .....

Question 10 continues on the next page

10 (c) Suggest **one** reason why chlorobenzene (C_6H_5Cl) does **not** react with ammonia under normal conditions.

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(1 mark)

(Extra space) .....

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13

Section B

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

6 Many synthetic routes need chemists to increase the number of carbon atoms in a molecule by forming new carbon–carbon bonds. This can be achieved in several ways including

- reaction of an aromatic compound with an acyl chloride
- reaction of an aldehyde with hydrogen cyanide.

6 (a) Consider the reaction of benzene with CH_3CH_2COCl

6 (a) (i) Write an equation for this reaction and name the organic product.
Identify the catalyst required in this reaction.
Write equations to show how the catalyst is used to form a reactive intermediate and how the catalyst is reformed at the end of the reaction.

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(5 marks)

(*Extra space)* .....

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6 (a) (ii) Name and outline a mechanism for the reaction of benzene with this reactive intermediate.

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(4 marks)

(Extra space) .....

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Question 6 continues on the next page

6 (b) Consider the reaction of propanal with HCN

6 (b) (i) Write an equation for the reaction of propanal with HCN and name the product.

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(2 marks)

(*Extra space)* .....

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6 (b) (ii) Name and outline a mechanism for the reaction of propanal with HCN

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(5 marks)

(Extra space) .....

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6 (b) (iii) The rate-determining step in the mechanism in part **6 (b) (ii)** involves attack by the nucleophile.
Suggest how the rate of reaction of propanone with HCN would compare with the rate of reaction of propanal with HCN
Explain your answer.

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(2 marks)

(Extra space) .....

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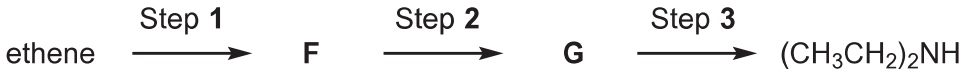
18

Turn over for the next question

7 The compound $(CH_3CH_2)_2NH$ can be made from ethene in a three-step synthesis as shown below.



7 (a) Name the compound $(CH_3CH_2)_2NH$

.....

(1 mark)

7 (b) Identify compounds **F** and **G**.

Compound **F** .....

Compound **G** .....

(2 marks)

7 (c) For the reactions in Steps **1**, **2** and **3**,

- give a reagent or reagents
- name the mechanism.

Balanced equations and mechanisms using curly arrows are **not** required.

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(6 marks)

(*Extra space*) .....

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7 (d) Identify **one** organic impurity in the product of Step **3** and give a reason for its formation.

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(2 marks)

(Extra space) .....

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11

END OF QUESTIONS