1. This question is about organic compounds containing nitrogen.

(a) Sodium cyanide, NaCN, can be reacted with many organic compounds to increase the length of a carbon chain.

(i) 1-Chloropropane, $CH_3CH_2CH_2Cl$, reacts with ethanolic sodium cyanide by nucleophilic substitution.

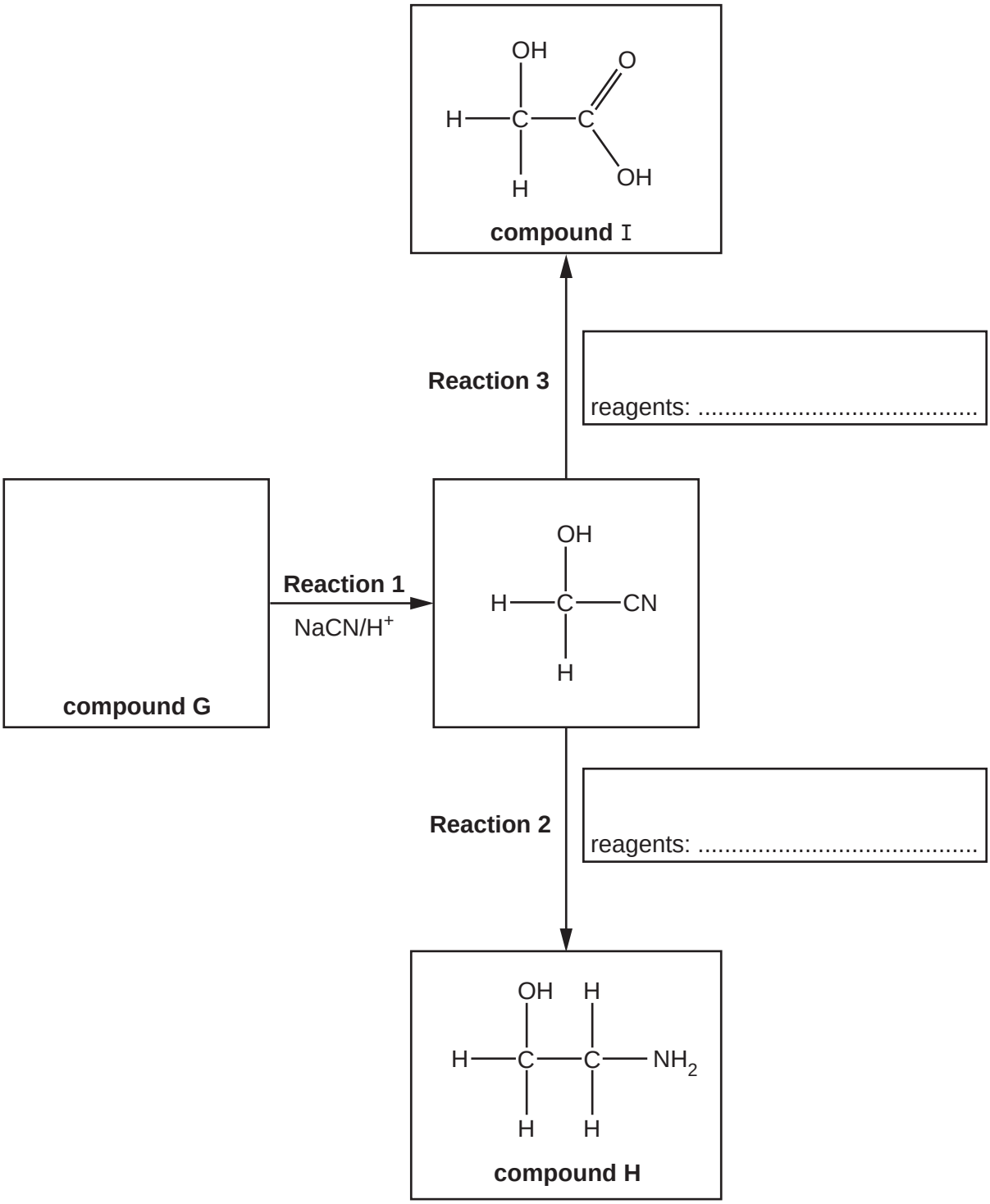
Outline the mechanism for this reaction.

Include curly arrows, relevant dipoles and the structure of the organic product.

[3]

(ii) Compound **G** is used to synthesise compounds **H** and **I** as shown in the flowchart below.

Complete the flowchart showing the structure of compound **G** and the **formulae** of the reagents for **Reaction 2** and **Reaction 3**.



[3]

(iii) Compound **H** reacts with dilute hydrochloric acid to form a salt.

Explain why compound **H** can react with dilute hydrochloric acid and suggest a structure for the salt formed.

Explanation .....

.....

.....

.....

Structure

[2]

(iv) Compound **I** is the monomer for the biodegradable polymer **J**.

Draw **two** repeat units of polymer **J** and suggest a reason why it is biodegradable.

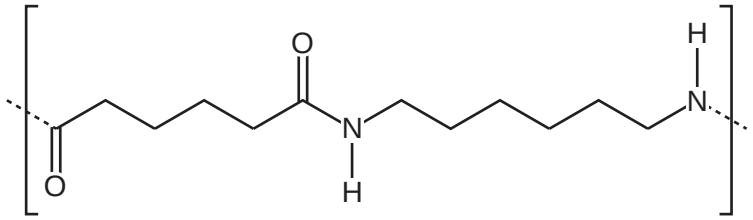
.....

.....

.....

..... **[3]**

(b) The repeat unit of Nylon 6,6 is shown below.



on

(i) Draw the structures of **two** monomers that can be used to form Nylon 6,6.

[2]

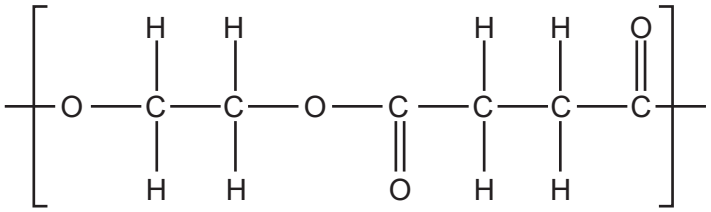
(ii) A sample of Nylon 6,6 has a relative molecular mass of 21500.

Estimate the number of repeat units in the sample.

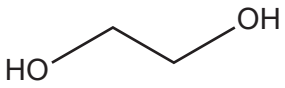
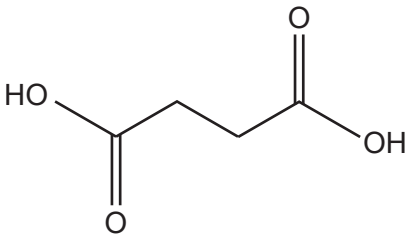
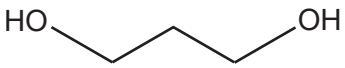
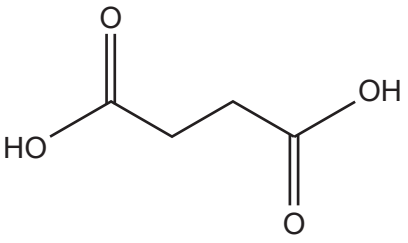
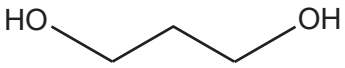
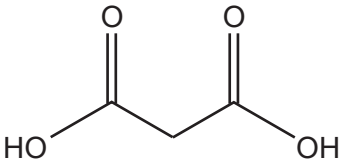
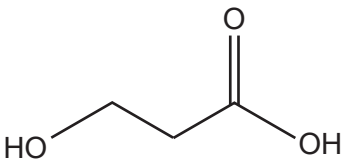
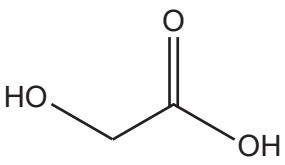
Give your answer as a **whole** number.

number of repeat units = ... **[1]**

2. The repeat unit of a polymer is shown below.



Which monomers could form this polymer?

A		
B		
C		
D		

Your answer ☐

[1]

3. This question is about benzene.

(a) Over time, the Kekulé and delocalised models have been used to describe the bonding and structure of a benzene molecule.

(i) Describe, in terms of orbital overlap, the similarities and differences between the bonding in the Kekulé model and the delocalised model of benzene.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

..... **[3]**

(ii) Experimental evidence led to the general acceptance of the delocalised model over the Kekulé model.

Describe **two** pieces of evidence to support the delocalised model of benzene.

.....

.....

.....

.....

.....

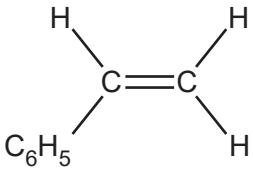
.....

.....

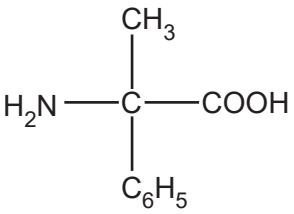
..... **[2]**

(b) Benzene can be used as the starting material for the synthesis of compounds **D** and **E**, shown below.

In the diagrams C_6H_5 is a phenyl group.



compound D



compound E

Compounds **D** and **E** can be converted into polymers.

(i) Draw **two** repeat units of these polymers.

Two repeat units of polymer formed from **D**

Two repeat units of polymer formed from **E**

[3]

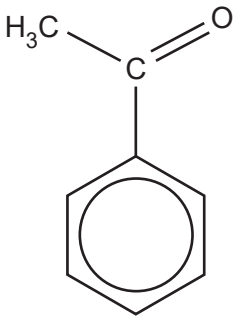
(ii) State the **type** of polymer formed from compounds **D** and **E**.

From compound **D** .....

From compound **E** .....

[1]

(iii) In the synthesis of compounds **D** and **E**, benzene is first reacted with ethanoyl chloride, CH_3COCl, to form phenylethanone, shown below.



phenylethanone

The reaction takes place in the presence of aluminium chloride, $AlCl_3$, which acts as a catalyst.

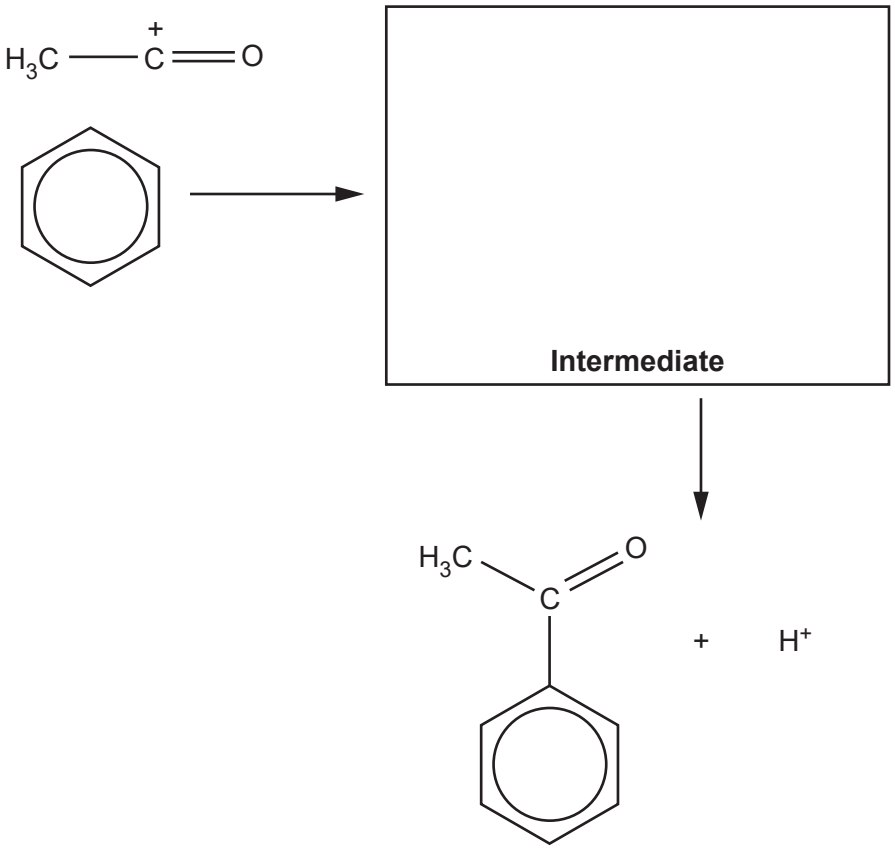
In the mechanism for this reaction,

- ethanoyl chloride first reacts with aluminium chloride to form the $CH_3–C^+=O$ cation
- the $CH_3–C^+=O$ cation then behaves as an electrophile.

Complete the mechanism for the reaction.

Include equations to show the role of the $AlCl_3$ catalyst, relevant curly arrows and the structure of the intermediate.

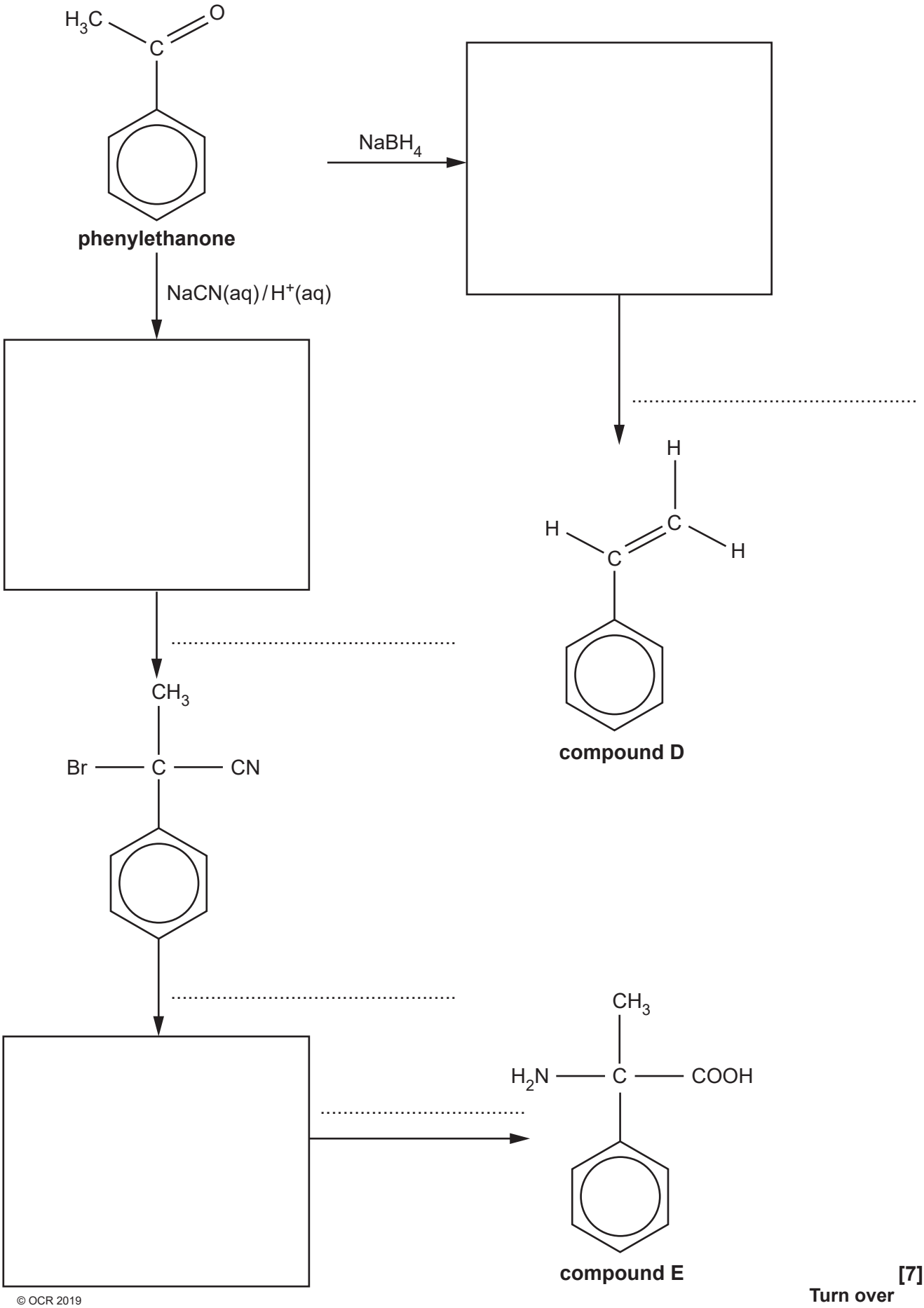
Formation of electrophile .....



Regeneration of catalyst .....

[5]

(iv) Complete the flowchart for the synthesis of compounds **D** and **E** from phenylethanone.



[7]

4. Alcohols can be used to prepare organic compounds with different functional groups.

(a) $HO(CH_2)_4OH$ can be oxidised to form $HOOC(CH_2)_2COOH$.

(i) State the reagents and conditions and write an equation for this oxidation.

In the equation, use [O] for the oxidising agent.

Reagents and conditions: .....

.....

Equation:

[3]

(ii) $HOOC(CH_2)_2COOH$ is soluble in water.

Explain, using a labelled diagram, why $HOOC(CH_2)_2COOH$ is soluble in water.

[2]

(b) $HOOC(CH_2)_2COOH$ and $HO(CH_2)_4OH$ react together to form polymer **E**.

(i) Draw **one** repeat unit of polymer **E**.

The functional groups should be clearly displayed.

[2]

(ii) Governments are encouraging the development of biodegradable polymers to reduce dependency on persistent plastic waste derived from fossil fuels.

Polymer **E** is a biodegradable polymer.

Suggest why polymer **E** is able to biodegrade.

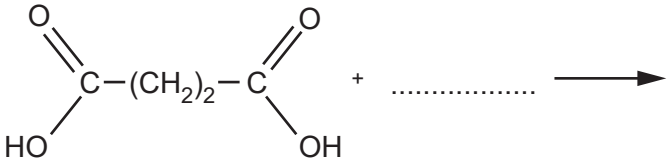
.....

..... **[1]**

(iii) A large yield of polymer **E** can be obtained by reacting a diacyl dichloride with $HO(CH_2)_4OH$.

The diacyl dichloride is prepared from $HOOC(CH_2)_2COOH$.

Complete the equation for the formation of a diacyl dichloride from $HOOC(CH_2)_2COOH$.



[3]