OCR
RECOGNISING ACHIEVEMENT

**ADVANCED GCE** **2814/01**

# CHEMISTRY

Chains, Rings and Spectroscopy

**MONDAY 18 JUNE 2007** Afternoon

Time: 1 hour 30 minutes

Additional materials: Scientific calculator
*Data Sheet for Chemistry* (Inserted)

*CUP/T24087*

Candidate Name

Centre Number

Candidate Number

**INSTRUCTIONS TO CANDIDATES**

- Write your name, Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Do **not** write in the bar code.
- Do **not** write outside the box bordering each page.
- WRITE YOUR ANSWER TO EACH QUESTION IN THE SPACE PROVIDED. ANSWERS WRITTEN ELSEWHERE WILL NOT BE MARKED.

**INFORMATION FOR CANDIDATES**

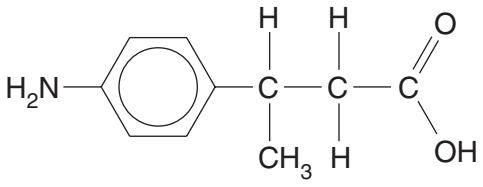
- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- You may be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- A copy of the *Data Sheet for Chemistry* is provided as an insert with this question paper.
- You are advised to show all the steps in any calculations.

| FOR EXAMINER'S USE | | |
|---|---|---|
| **Qu.** | **Max.** | **Mark** |
| **1** | **10** | |
| **2** | **17** | |
| **3** | **7** | |
| **4** | **10** | |
| **5** | **12** | |
| **6** | **13** | |
| **7** | **21** | |
| **TOTAL** | **90** | |

This document consists of **16** printed pages and a *Data Sheet for Chemistry*.

Answer **all** the questions.

**1** Compound **A**, shown below, is an amino acid that is being used in the development of a new anti-inflammatory drug.




compound **A**

**(a) (i)** Explain why this molecule is described as an *amino acid*.

.....

..... [1]

**(ii)** State the general formula of an $\alpha$-amino acid.

Explain whether or not compound **A** fits this general formula.

.....

..... [2]

**(b)** Compound **A** can be synthesised from 3-chlorobutanoic acid, $CH_3CHClCH_2COOH$. One step in this synthesis involves the reaction of 3-chlorobutanoic acid with benzene using a suitable catalyst.

**(i)** Complete the equation for this reaction.

$CH_3CHClCH_2COOH$ + $\longrightarrow$ $C_6H_5CH(CH_3)CH_2COOH$ +

[1]

**(ii)** State the type of reaction.

..... [1]

**(iii)** Identify a suitable catalyst for this reaction.

..... [1]

**(c)** Compound **A** exists as a zwitterion in aqueous solution.

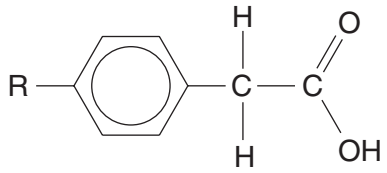
**(i)** Draw the structure of this zwitterion.

[1]

**(ii)** Show how the structure of the zwitterion would change if the solution was acidified with dilute hydrochloric acid.

[1]

**(d)** The anti-inflammatory drug is made by combining compound **A** with compound **B**, shown below. R represents a side chain.



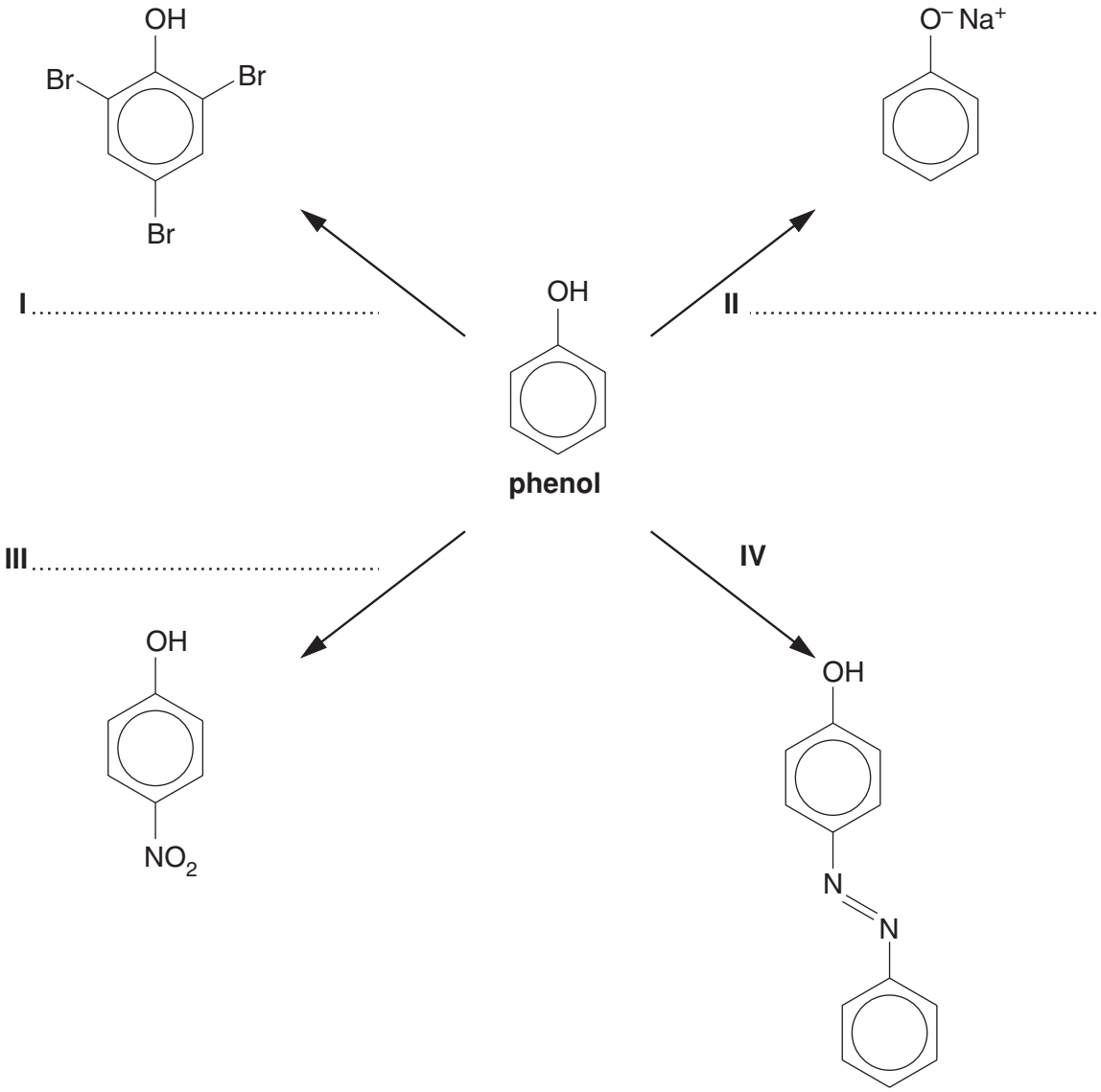

compound **B**

Show the structure of the anti-inflammatory drug formed from compound **A** and compound **B**.

[2]

[Total: 10]

**2** The diagram below shows some reactions of phenol.




**(a)** **(i)** On the diagram above, identify suitable reagents that could be used to carry out reactions **I**, **II** and **III**. [3]

**(ii)** State a use for the compound formed in reaction **IV**.

..... [1]

**(iii)** Outline how you could carry out reaction **IV** in the laboratory starting from phenol and a suitable aromatic amine.

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..... [5]

**(b)** In this question, one mark is available for the quality of spelling, punctuation and grammar.

Phenol reacts much more readily with bromine than benzene does.

- Describe, with the aid of a diagram, the bonding in benzene.
- Explain why electrophiles, such as bromine, react much more readily with phenol than with benzene.

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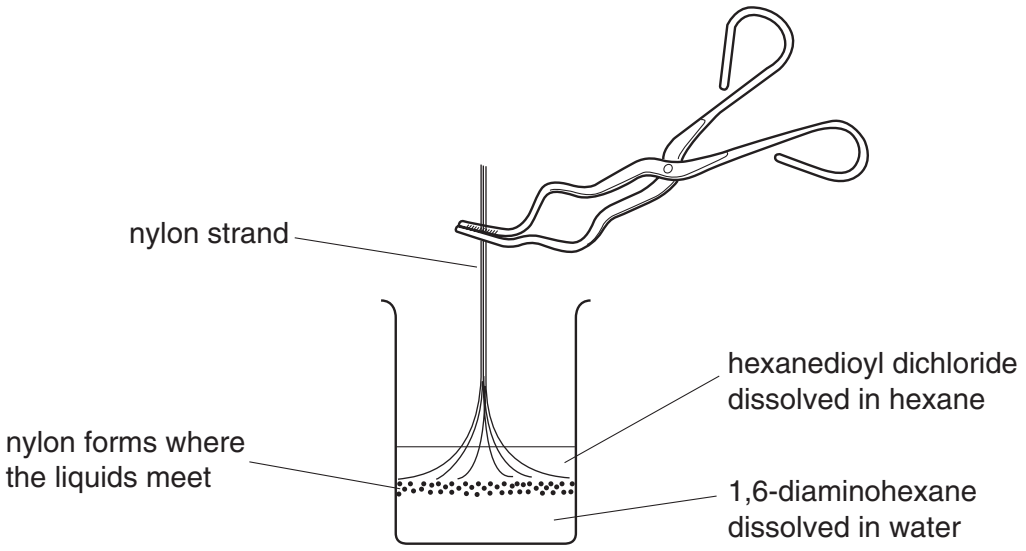
..... [7]

Quality of Written Communication [1]

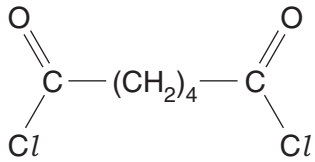
[Total: 17]

**3** The 'Nylon Rope Trick' is a well-known laboratory demonstration for the formation of a condensation polymer from its monomers.

Two solutions, one containing each monomer, are placed in a beaker as shown. In this reaction, the more reactive hexanedioyl dichloride is used instead of hexanedicarboxylic acid. The nylon forms where the two immiscible liquids join, and can be pulled out from between the layers in a continuous strand.




**(a)** Complete the equation below to show the formation of the nylon polymer from its monomers. Show a repeat unit for the polymer and the other product formed.




hexanedioyl dichloride

+

1,6-diaminohexane

repeat unit of polymer

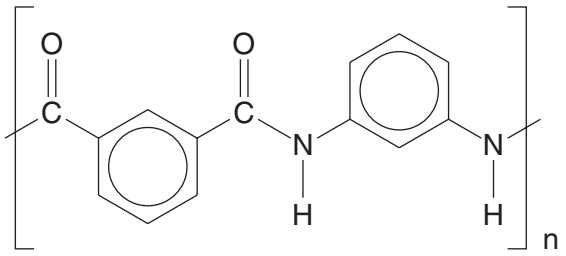
+

other product

[4]

**(b)** Nylon is sometimes used for electrical insulation. However, if there is a risk of high temperatures then a polymer such as Nomex®, with a higher melting point, is used.

The repeat unit of Nomex® is shown below.




**(i)** Draw the structures of two monomers that could be used to form Nomex®.

[2]

**(ii)** Suggest a reason why the melting point of Nomex® is higher than that of nylon.

.....

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..... [1]

[Total: 7]

**4** But-2-enal, $CH_3CH=CHCHO$, is a pale yellow, flammable liquid with an irritating odour.

**(a)** But-2-enal exists as two stereoisomers.

Draw skeletal formulae to show the structure of the two stereoisomers of but-2-enal.

[2]

**(b)** **(i)** Describe a simple chemical test that would show that but-2-enal is an aldehyde.

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.....

..... [2]

**(ii)** Explain why this test gives a different result with aldehydes than it does with ketones.

.....

..... [1]

**(c)** But-2-enal also reacts with sodium borohydride, $NaBH_4$.

**(i)** Identify the organic compound formed in this reaction.

..... [1]

**(ii)** State the type of chemical reaction occurring.

..... [1]

**(d)** Precautions must be taken to prevent but-2-enal catching fire.

Construct a balanced equation for the complete combustion of but-2-enal, $C_4H_6O$.

[1]

**(e)** But-2-enal will polymerise rapidly in the presence of a suitable catalyst.

**(i)** Draw the structure of the polymer showing at least **two** repeat units.

[1]

**(ii)** One of the polymers formed by this reaction is *atactic*.

State the meaning of the term *atactic*.

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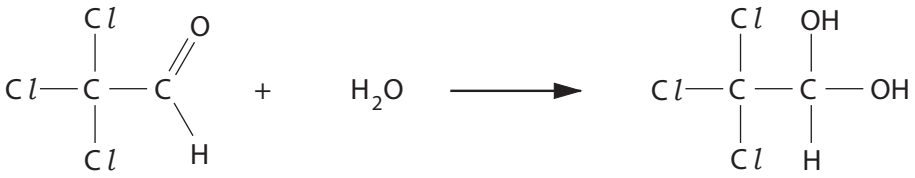
..... [1]

[Total: 10]

5 Chloral hydrate (2,2,2-trichloroethane-1,1-diol) is a sedative that is made by adding trichloroethanal to water. An equation for this reaction is shown below.



trichloroethanal chloral hydrate

(a) The infra-red spectrum shown below is either that of trichloroethanal or chloral hydrate.

**A graph has been removed due to third party copyright restrictions**

Details:

An infra-red spectrum of one of the two chemicals listed



State which compound produced this spectrum. Explain your reasoning by referring to the presence and absence of three relevant peaks.

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.....

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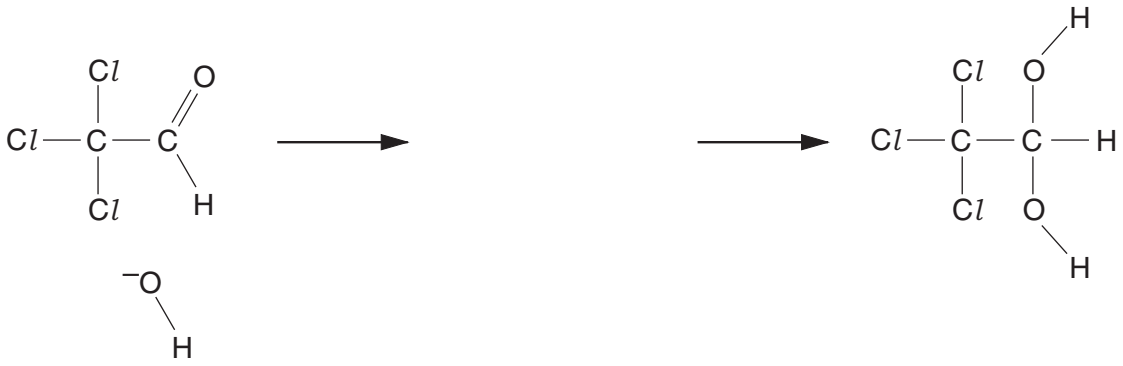
.....

..... [3]

**(b)** The reaction of trichloroethanal with water is a nucleophilic addition reaction. It can be catalysed by small amounts of hydroxide ions, $OH^-$.

Complete the diagram below to suggest a mechanism for this reaction. Show all the relevant dipoles and curly arrows.




[5]

**(c)** The recommended adult dose of chloral hydrate as a sedative is 250 mg, three times a day.

Calculate the mass of **trichloroethanal** you would need to react with water to make one week's supply of chloral hydrate for an adult, assuming a 60% yield.

$M_r$: chloral hydrate, 165.5; trichloroethanal, 147.5

mass of trichloroethanal = …… g [3]

**(d)** Chloral hydrate is broken down in the body after several hours. One reaction is oxidation to trichloroethanoic acid.

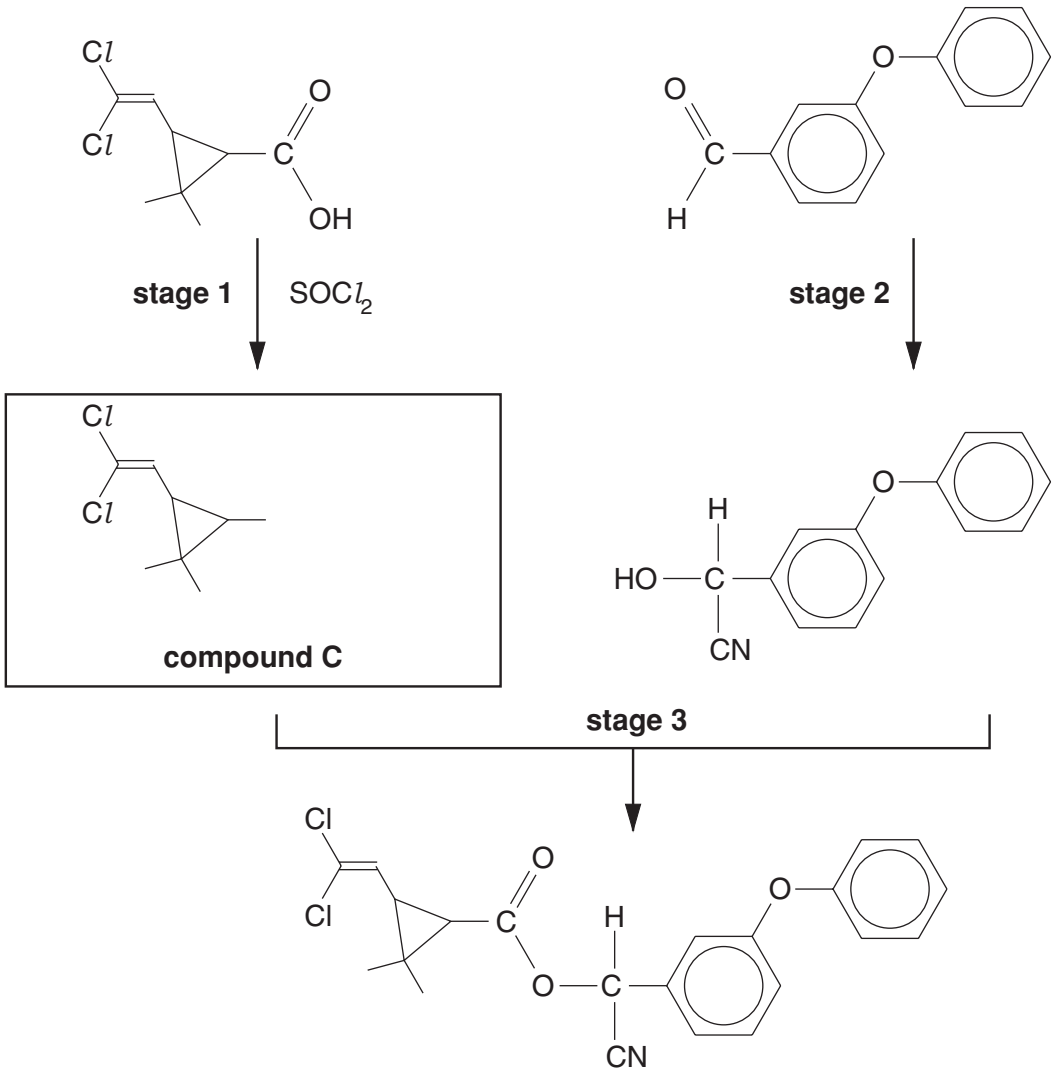
Complete the equation for this reaction below.

$Cl_3CCH(OH)_2$ + [O] ⟶

[1]

[Total: 12]

**6** The scheme below shows the final stages in the synthesis of *cypermethrin*, which is widely used today as an insecticide.




***cypermethrin***

**(a) (i)** Deduce the number of carbon atoms in a molecule of *cypermethrin*.

..... [1]

**(ii)** Complete the structure of the organic **compound C** in the box above. [1]

**(iii)** Name the functional group that is formed in **stage 3**.

..... [1]

**(iv)** Identify suitable reagents to carry out **stage 2**.

..... [1]

**(v)** State the type of chemical reaction occurring in **stage 2**.

..... [1]

**(b)** One company manufacturing the insecticide uses an enzyme to catalyse the reaction in **stage 2**. *Cypermethrin* made by this method can be used in smaller doses than *cypermethrin* made by the normal laboratory conditions.

Suggest an explanation.

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..... [3]

**(c)** *Cypermethrin* does not remain on crops because it is broken down in the environment by hydrolysis. It can also be rapidly hydrolysed in the laboratory using an acid catalyst.

**(i)** State how you would carry out acid hydrolysis of *cypermethrin* in the laboratory.

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..... [2]

**(ii)** Suggest the structures of **two** organic compounds that could be produced by acid hydrolysis of *cypermethrin*.

[3]

[Total: 13]

**7** An ester **D** with the formula, $CH_3CH_2COOCH_2CH(CH_3)_2$, is used in rum flavouring.

**(a)** Draw a displayed formula of ester **D**.

[2]

**(b)** Outline how you could obtain a sample of ester **D**, starting with a named carboxylic acid and a named alcohol.

Include any essential reaction conditions and write an equation for the reaction. You do not need to include any details of the separation or purification of the ester.

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..... [6]

**(c)** State a spectroscopic method that could be used to confirm that a sample of ester **D** has a molecular mass of 130.

Explain how you would obtain the molecular mass of **D** from the spectrum.

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..... [2]

**(d) (i)** In this question, one mark is available for the quality of the use and organisation of scientific terms.

Describe and explain the different ways that a high resolution n.m.r. spectrum can give information about a molecule.

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Quality of Written Communication [1]

**TURN OVER FOR PART (d)(ii)**

(ii) The n.m.r. spectrum of ester D, $CH_3CH_2COOCH_2CH(CH_3)_2$, is shown below.

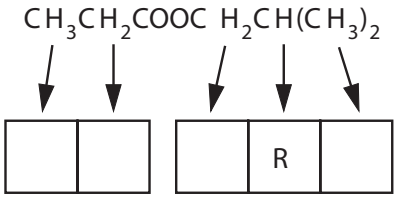
**A graph has been removed due to third party copyright restrictions**

Details:

The n.m.r spectrum of ester
D, $CH_3CH_2COOCH_2CH(CH_3)_2$



Fill in the boxes below to identify which protons in ester D are responsible for peaks labelled P to T on the spectrum. Peak R has been identified for you.




[3]

[Total: 21]

END OF QUESTION PAPER