

**OXFORD CAMBRIDGE AND RSA EXAMINATIONS**

**Advanced GCE**

**CHEMISTRY**

Chains, Rings and Spectroscopy

**2814**

Thursday

**23 JUNE 2005**

Afternoon

1 hour 30 minutes

Candidates answer on the question paper.

Additional materials:

*Data Sheet for Chemistry*

Scientific calculator

Candidate Name	Centre Number	Candidate Number									
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**TIME** 1 hour 30 minutes

**INSTRUCTIONS TO CANDIDATES**

- Write your name in the space above.
- Write your Centre number and Candidate number in the boxes above.
- Answer **all** the questions.
- Write your answers in the spaces provided on the question paper.
- Read each question carefully and make sure you know what you have to do before starting your answer.

**INFORMATION FOR CANDIDATES**

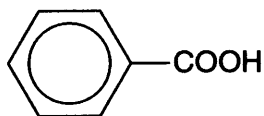
- The number of marks is given in brackets [ ] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry*.
- You are advised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

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	10	
2	15	
3	13	
4	15	
5	20	
6	17	
<b>TOTAL</b>	<b>90</b>	

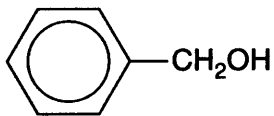
**This question paper consists of 16 printed pages.**

Answer all the questions.

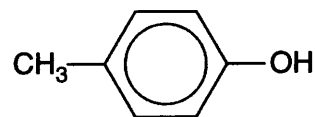
- 1 A student decided to investigate the reactivity of the  $-OH$  group in the three organic compounds shown below.



benzoic acid



phenylmethanol



4-methylphenol

- (a) Benzoic acid reacts with aqueous sodium hydroxide.



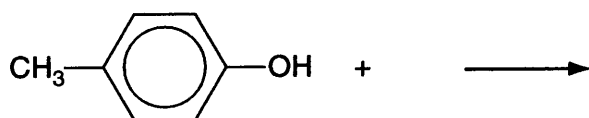
- (i) Complete the equation above. [2]  
 (ii) State which, if any, of the other two compounds above would react with aqueous sodium hydroxide. Explain your answer.

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

- (b) All three compounds react with sodium metal, giving off a gas.

- (i) Identify the gas given off in this reaction.  
 ..... [1]

- (ii) Complete and balance the equation for the reaction of 4-methylphenol with sodium.



[2]

(c) Benzoic acid and phenylmethanol will react with each other in the presence of a suitable catalyst.

(i) State a suitable catalyst for this reaction.

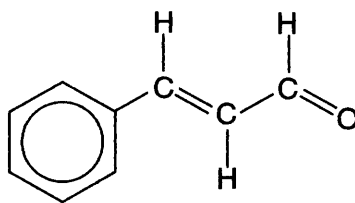
.....[1]

(ii) Draw the displayed formula of the organic product.

[2]

[Total: 10]

- 2 Cinnamaldehyde is the compound that gives cinnamon its distinctive flavour.



**cinnamaldehyde**

- (a) Draw the skeletal formula of cinnamaldehyde.

[1]

- (b) Cinnamaldehyde shows *cis-trans* isomerism.

- (i) Explain how *cis-trans* isomerism arises in cinnamaldehyde.

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

- (ii) State and explain whether cinnamaldehyde is a *cis* or a *trans* isomer.

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

- (iii) Draw a skeletal or displayed formula to show the structure of the other *cis-trans* isomer of cinnamaldehyde.

[1]

- (c) Cinnamaldehyde can be reduced using sodium borohydride,  $\text{NaBH}_4$ .

- (i) State which functional group reacts with the sodium borohydride.

.....[1]

- (ii) Complete and balance the equation for this reaction.



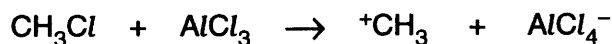
[1]



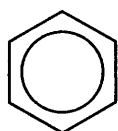
- 3 Benzene reacts with  $\text{CH}_3\text{Cl}$  to form methylbenzene  $\text{C}_6\text{H}_5\text{CH}_3$ . This is an electrophilic substitution reaction.

A possible mechanism for this reaction is shown below.

**Step 1:** the electrophile  $^+\text{CH}_3$  is formed from  $\text{CH}_3\text{Cl}$  and the catalyst,  $\text{AlCl}_3$



**Steps 2 and 3:** substitution of  $^+\text{CH}_3$  into the benzene ring



step 2  
→

step 3  
→

intermediate

products

**Step 4:** the catalyst,  $\text{AlCl}_3$ , is regenerated

- (a) (i) Complete **steps 2 and 3** of the mechanism above. Show the relevant curly arrows and the charges on any ions. [4]

- (ii) State why  $^+\text{CH}_3$  is described as an electrophile in this mechanism.

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

- (iii) Suggest an equation to show how the catalyst,  $\text{AlCl}_3$ , is regenerated in **step 4**.

[1]

- (b) Write an overall equation for this reaction.

[2]

(c) This substitution reaction occurs much more readily with phenol than with benzene.

(i) State and explain why electrophilic substitution reactions occur much more readily with phenol than with benzene.

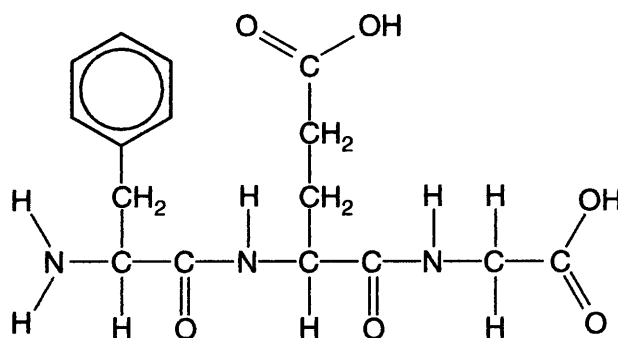
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.....  
.....  
.....  
.....  
.....  
.....[4]

(ii) Suggest a structure for the most likely organic product formed in the substitution reaction of phenol with **excess**  $\text{CH}_3\text{Cl}$ .

[1]

[Total: 13]

- 4 Compound **A** is currently being tested as a possible anti-allergic drug.



compound **A**

- (a) Compound **A** can be hydrolysed to form three organic products.

- (i) Name a suitable reagent and conditions for the hydrolysis of compound **A**.

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

- (ii) The three organic products all belong to the same class of compound. State the general name for this class of organic compound.

.....[1]

- (iii) Draw the structure of **one** of the organic products from the hydrolysis of **A** using the reagent you have given in (a)(i) above.

[2]

- (iv) Explain what is meant by the term *hydrolysis*. Use this reaction to illustrate your answer.

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



(b) Compound **A** can exist as a number of stereoisomers, but only one of them is pharmacologically active as the anti-allergic drug.

(i) Explain what causes stereoisomerism in compounds such as **A**.

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

(ii) Explain why there are **four** different stereoisomers of compound **A**.

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

(iii) Suggest how a drug company could synthesise compound **A** so that the drug contains only the pharmacologically active stereoisomer.

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

(iv) Sometimes it is difficult to manufacture a drug containing only the one pharmacologically active stereoisomer.

Describe **two** possible disadvantages of producing a drug containing a mixture of several stereoisomers.

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

[Total: 15]

- 5 1,4-Diaminobenzene is used in the manufacture of a variety of materials including dyes and polymers.

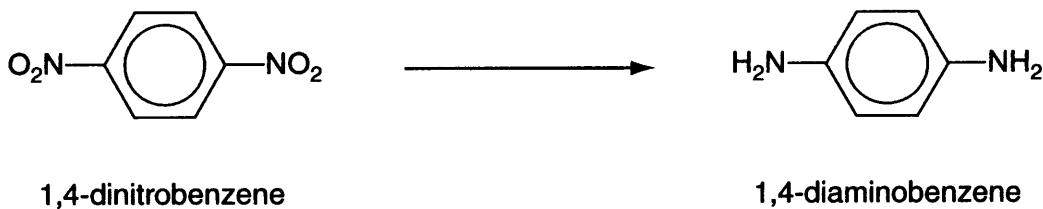


**1,4-diaminobenzene**

- (a) Explain what is meant by the term *1,4-diamino* in the name of this compound.

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

- (b) 1,4-diaminobenzene can be manufactured from 1,4-dinitrobenzene.



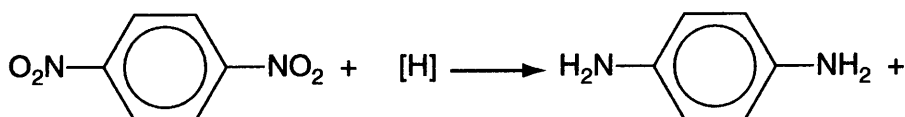
- (i) What type of reaction is this?

.....[1]

- (ii) State reagents and conditions that could be used to carry out this reaction.

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

- (iii) Complete and balance the equation below for this reaction.



[2]

(c) 1,4-Diaminobenzene is used to make permanent black dye for hair.

1,4-Diaminobenzene can irritate the skin because it is basic. Therefore, it is sometimes neutralised with **excess** hydrochloric acid to give the salt.

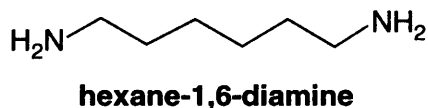
(i) Explain how the amino groups in a primary amine such as 1,4-diaminobenzene allow the molecule to act as a base.

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

(ii) Draw the structure of the salt formed in this reaction.

[2]

(iii) State whether you would expect hexane-1,6-diamine to be a stronger or weaker base than 1,4-diaminobenzene. Explain your reasoning.



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

(d) Kevlar is a very tough polymer made from 1,4-diaminobenzene and benzene-1,4-dicarboxylic acid.

(i) State a use for Kevlar.

.....[1]

(ii) Describe the polymerisation reaction that forms Kevlar. Include in your answer:

- an explanation of the type of polymerisation involved
- an equation for the reaction
- a repeat unit to show the structure of Kevlar.

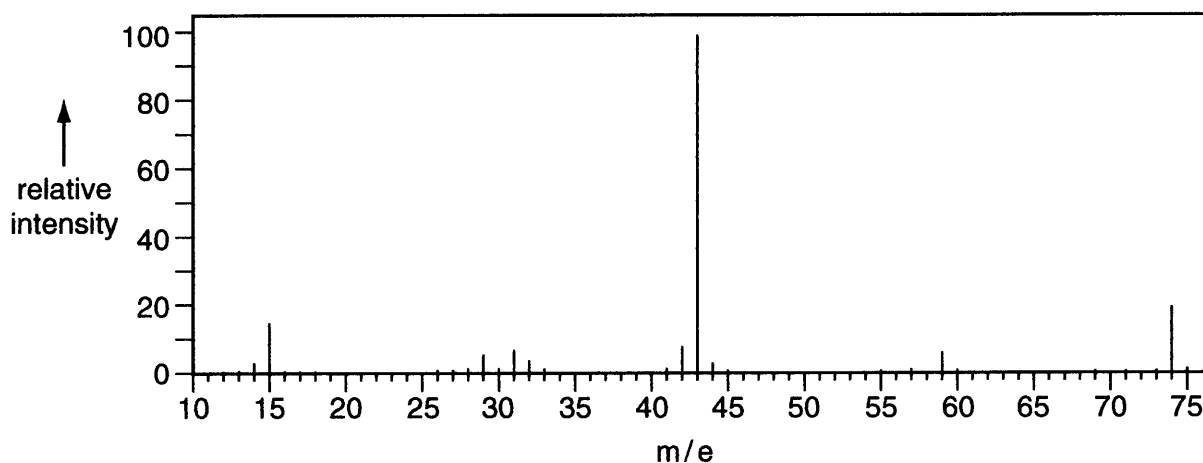
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.....[5]

[Total: 20]

6 An unknown organic compound **X** was analysed as follows.

(a) Elemental analysis showed that compound **X** had an empirical formula of  $C_3H_6O_2$ .

The mass spectrum of **X** is shown below.



Show how the molecular formula of compound **X** can be deduced from the information above. Explain your reasoning. Circle the peak you have used on the spectrum.

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

(b) (i) Compound **X** did **not** give a precipitate with 2,4-dinitrophenylhydrazine.

State what this tells you about compound **X**.

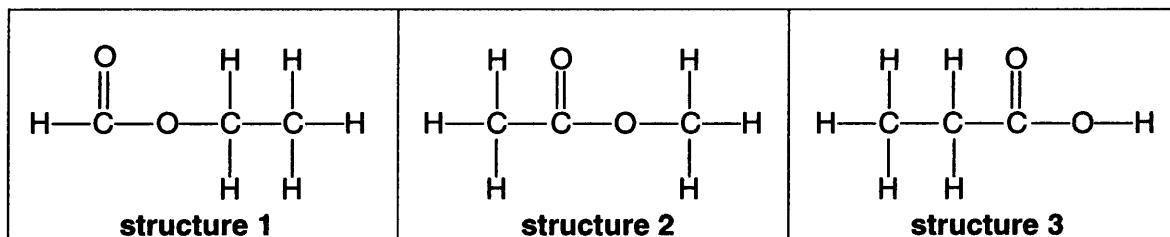
.....  
 ..... [1]

(ii) Compound **X** did **not** decolourise bromine water.

State what this tells you about compound **X**.

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

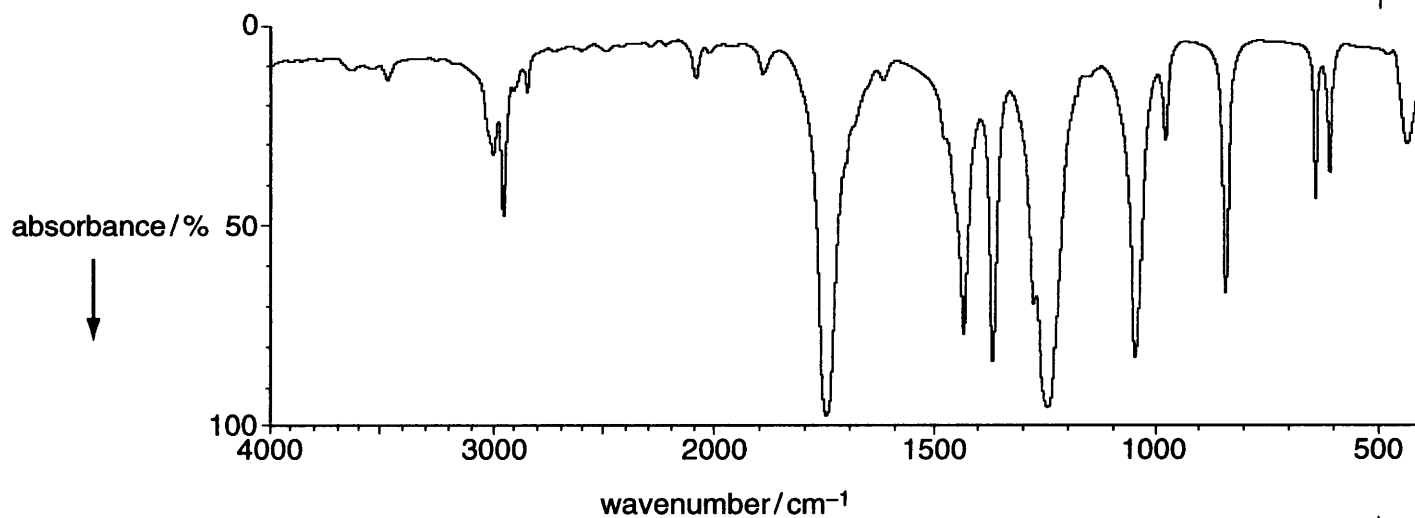
(c) Three structures for compound **X** were suggested.



State the name of: **structure 1** .....

**structure 3** .....[2]

(d) The infra-red spectrum of compound **X** is shown below.



For **each** of the three **structures 1 to 3**, state whether this spectrum supports its identity as compound **X** or not. Explain your reasoning by commenting on the presence or absence of the relevant peaks.

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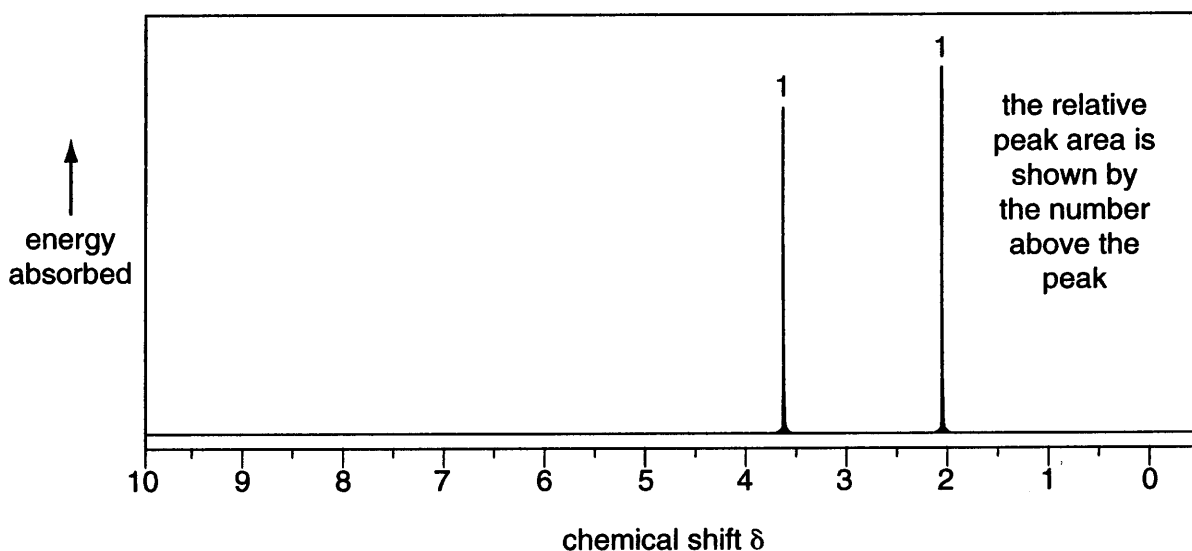
.....

.....

.....[4]

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

The n.m.r. spectrum of compound X is shown below.



Use this spectrum to conclusively identify the structure of compound X. Explain your reasoning clearly by showing why the structure you have suggested would give rise to this spectrum. Refer to the  $\delta$  value of each peak, the relative peak areas and the lack of peak splitting.

correct structure of compound X:

reasoning:

.....[5]

Quality of Written Communication. [1]

[Total: 17]

END OF QUESTION PAPER