

OXFORD CAMBRIDGE AND RSA EXAMINATIONS

Advanced GCE

CHEMISTRY (SALTERS)

Chemistry of Materials



2849

Monday

19 JUNE 2006

Afternoon

1 hour 30 minutes

Candidates answer on the question paper.

Additional materials:

Data Sheet for Chemistry (Salters)

Scientific calculator

Candidate
Name

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Centre
Number

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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.
- Read each question carefully and make sure you know what you have to do before starting your answer.
- Write your answers, in blue or black ink, in the spaces provided on the question paper. Pencils may be used for diagrams and graphs **only**.
- Do not write in the bar code. Do not write in the grey area between the pages.
- **DO NOT WRITE IN THE AREA OUTSIDE THE BOX BORDERING EACH PAGE. ANY WRITING IN THIS AREA WILL NOT BE MARKED.**

FOR EXAMINER'S USE		
Qu.	Max.	Mark
1	17	
2	24	
3	23	
4	15	
5	11	
TOTAL	90	

INFORMATION FOR CANDIDATES

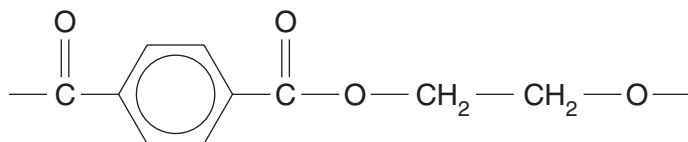
- The number of marks is given in brackets [] at the end of each question or part question.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry (Salters)*.
- You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

This question paper consists of 15 printed pages and 1 blank page.

Answer **all** the questions.

- 1 Non-returnable drinks bottles are often made from **PET**. This produces a huge problem for waste disposal. However, this polymer cannot be used to make returnable bottles.

(a) **PET** is a polyester. The repeating unit for **PET** is given below.



(i) Draw a ring around the ester group in the repeating unit above. [1]

(ii) One of the monomers from which **PET** is made is ethane-1,2-diol.

Draw the full structural formula of ethane-1,2-diol.

[1]

(b) Plastic waste is often buried for disposal. Give **one** other method which is used to dispose of plastics and explain an advantage of this method.

.....

 [2]

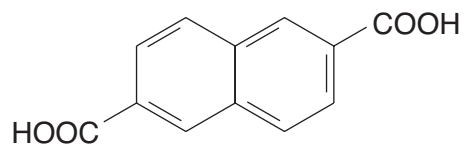
(c) **PET** is not used to make returnable bottles because its glass transition temperature, T_g , is too low. The glass transition temperature of a polymer is the temperature at which it changes from being flexible to becoming brittle.

Explain why lowering the temperature of a polymer below its T_g causes it to become brittle.

.....

 [3]

- (d) Chemists have recently developed a new polyester which can be used for producing returnable bottles. It can be made from ethane-1,2-diol and compound **A**. The structure of compound **A** is shown below. The polymer is known as **PEN**.



compound A

- (i) Draw the **skeletal** formula of the repeating unit of **PEN**.

[2]

- (ii) **PEN** has a higher T_g and melting temperature than **PET**. Assume both polymers have similar average relative molecular masses. Suggest why **PEN** has a higher melting temperature than **PET**.

.....

.....

.....

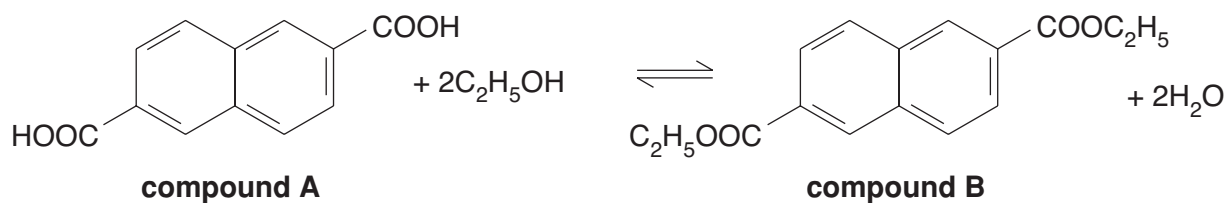
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..... [2]

(e) Industrially, **PEN** can be made by reacting a diester of compound **A** with ethane-1,2-diol.

Compound **A** will react with ethanol according to the equation below. The forward reaction is exothermic.



(i) Write the expression for the equilibrium constant, K_c , for this reaction. Use **A** and **B** in your expression to represent the diacid and the diester.

[2]

(ii) Describe and explain the effect of increasing the temperature on the equilibrium constant, K_c , for this reaction.

.....

 [2]

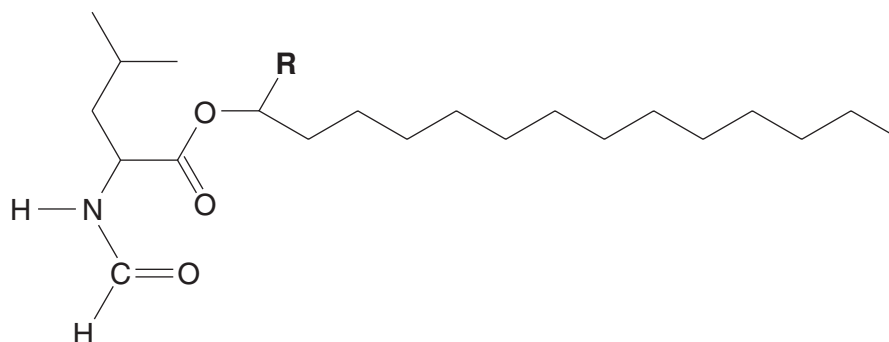
(iii) What other chemical is added to an acid and alcohol mixture to make an ester in the laboratory? Give the conditions used.

chemical added

conditions [2]

[Total: 17]

- 2 Xenical is a new weight-control drug for the long-term treatment of obesity. The active ingredient in Xenical is a compound, called orlistat, whose structure is shown below. **R** represents a carbon chain containing a functional group.



orlistat

- (a) Orlistat is a chiral molecule. Label **two** chiral centres on the structure above with asterisks. [1]
- (b) On the structure of orlistat, circle an amide group. [1]
- (c) Hydrolysis of orlistat produces a mixture of several organic compounds. One of these is an amino acid.
- (i) Give the reagent and the conditions used for hydrolysing orlistat.
- reagent
- conditions [2]
- (ii) What technique is used to determine the M_r of the amino acid?
- [1]
- (iii) Describe using diagrams and words how paper chromatography is used to show the presence of this amino acid in the mixture.

- (iv) One of the other compounds which could be obtained from the hydrolysis mixture is a carboxylic acid. The chemical shifts and intensities of the peaks in the proton n.m.r. spectrum of this acid are given in the table below.

chemical shift	relative intensity
10.0	1
13.0	1

Draw the full structural formula for this carboxylic acid and explain how you used the data.

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

- (v) Carboxylic acids and alcohols both contain the hydroxyl group. The hydroxyl group in a carboxylic acid makes the compound weakly acidic whereas alcohols are neutral.

Explain how differences in chemical structure produce differences in the acidic behaviour of the hydroxyl group.

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

(d) The group **R** in orlistat contains an ester group.

(i) Explain how molecules absorb infrared radiation.

Describe how infrared spectra can be used to show the presence of particular functional groups.

Give details of any absorption peaks you would look for in the infrared spectrum of an ester.

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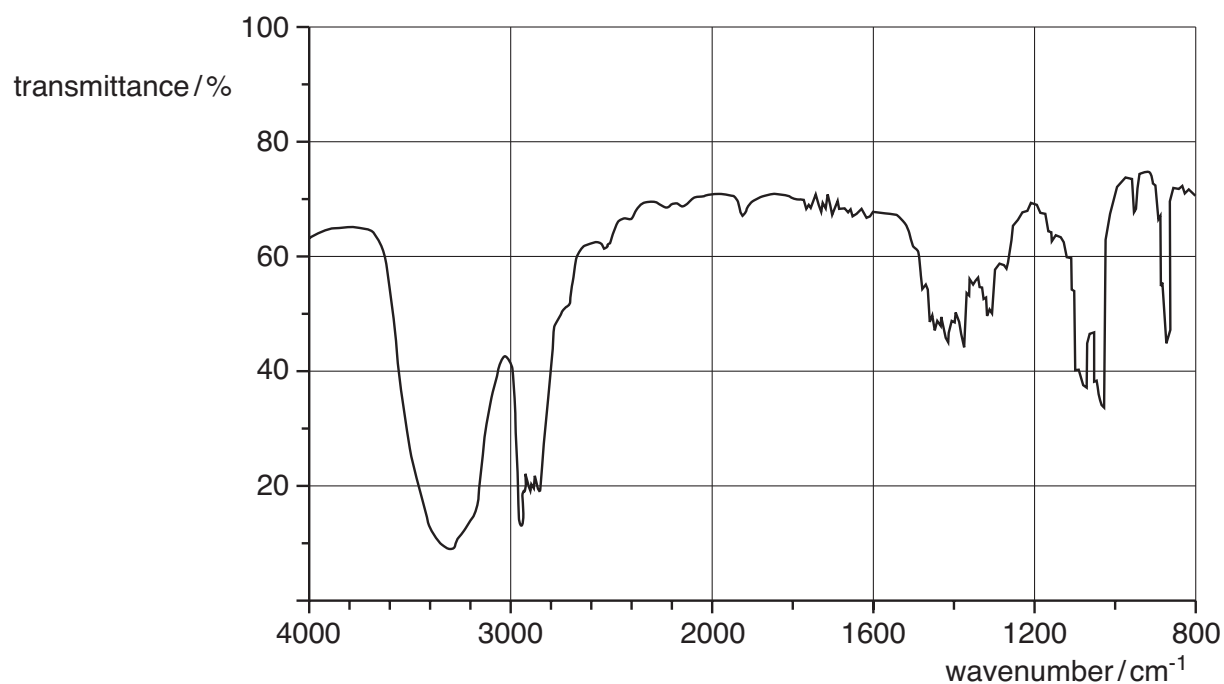
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.....

..... [4]

(ii) Hydrolysis of the ester group in group **R** using alkaline conditions gives compound **C**.

The infrared spectrum of compound **C** is shown below. Identify the functional group present in compound **C**. Give a reason for your answer.



.....

.....

..... [2]

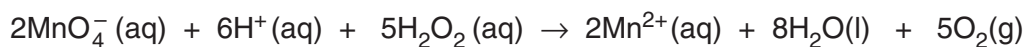
[Total: 24]

[Turn over

- (ii) A solution of hydrogen peroxide is diluted by a factor of 10.0.

10.0 cm³ of this diluted H₂O₂ reacted with exactly 18.2 cm³ of 0.0200 mol dm⁻³ MnO₄⁻ solution.

The equation for the reaction taking place is given below.



Calculate the concentration of the **undiluted** H₂O₂ solution.

Give your answer to **an appropriate number** of significant figures.

concentration = mol dm⁻³
[4]

- (iii) The concentration of the hydrogen peroxide solution used for treating paintings must not be greater than 3.0%. Assume this means 3.0 g of H₂O₂ in 100 cm³ of solution.

Is the undiluted solution of H₂O₂ suitable to be used for treating paintings?

Show your working. A_r: H, 1.0; O, 16

..... [2]

- (c) Restorers of paintings are instructed to store hydrogen peroxide solutions in polythene bottles rather than glass ones. Glass acts as a catalyst for the decomposition of hydrogen peroxide.

They are also told to make up the solutions with pure water rather than tap water. Traces of transition metal ions present in tap water can also catalyse the decomposition of hydrogen peroxide.

- (i) Write the equation for the decomposition of hydrogen peroxide into water and oxygen.

Give the state symbols.



[1]

- (ii) Glass acts as a heterogeneous catalyst, whereas transition metal ions are homogeneous catalysts.

Explain this difference.

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

- (iii) A solution of hydrogen peroxide stored in a glass bottle at room temperature was found to be completely decomposed after two weeks.

Describe an experimental procedure which measures the **volume** of oxygen produced.

Show how you would use your results to find the initial rate of the decomposition reaction.

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

- (iv) The reaction is found to be first order with a rate constant of $2.0 \times 10^{-6} \text{ s}^{-1}$ at 298 K.

Calculate the rate of decomposition of a 2.0 mol dm^{-3} hydrogen peroxide solution at 298 K.

rate of decomposition = $\text{mol dm}^{-3} \text{ s}^{-1}$ [2]

[Total: 23]

11
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[Turn over

4 Groundwater usually contains iron compounds and therefore water from wells will contain significant amounts of iron. The main problem with household water containing iron is the staining it causes to laundry, porcelain and plumbing fittings.

(a) Water containing iron in an oxidation state of +2 is known as 'clear water' since it appears colourless. However, on leaving the tap it may become coloured and is then referred to as 'red water'. 'Red water' contains iron(III) compounds.

(i) What causes the colour change as the water leaves the tap?

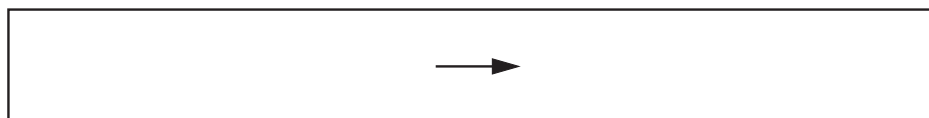
.....
 [2]

(ii) Which complex ion causes the 'red' colour?

..... [1]

(iii) If the 'red water' becomes slightly alkaline, a red-brown precipitate will form.

Write an ionic equation for the formation of the red-brown precipitate. Include state symbols.



[3]

(b) 'Iron stains' contain iron(III) compounds and can be removed using a variety of products available in the supermarket. One commonly used chemical is ethanedioic acid. It is used in stain removers as the disodium salt.

(i) Draw the full structural formula of the ethanedioate ion, $C_2O_4^{2-}$.

[1]

(ii) Ethanedioate ions in aqueous solution react with 'red water' to form green $[Fe(C_2O_4)_3]^{3-}$ ions.

Name the type of reaction [1]

(iii) Explain why $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$ ions appear green in aqueous solution.

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

(iv) What is the coordination number in $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$?

Explain what the term means.

coordination number

explanation

..... [3]

(v) Draw the three-dimensional structure of an $[\text{Fe}(\text{C}_2\text{O}_4)_3]^{3-}$ ion showing clearly how the ligands bond to the central cation.

[2]

[Total: 15]

[Turn over

5 Now that chemists have unlocked the significance of the DNA structure and developed experimental methods, DNA technology is being used by people tracing their family histories.

(a) DNA is a polymer made from monomers called nucleotides. A nucleotide consists of a five-carbon sugar joined to a phosphate group and a nitrogen-containing ring structure which is a base.

(i) Explain how organic compounds containing nitrogen atoms act as bases.

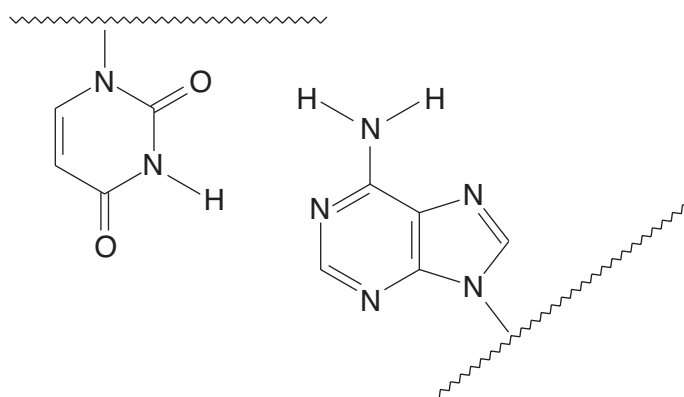
.....
 [2]

(ii) The polymerisation of nucleotides to form DNA is a condensation reaction.

Identify the other substance formed in this reaction.

..... [1]

(iii) DNA is formed from two polynucleotide chains. These chains are held together by interactions between base units on adjacent chains. On the diagram below, show clearly these interactions including any relevant lone pairs and partial charges.



[3]

(iv) What is the shape of a DNA molecule?

.....[1]

(b) DNA is used in the synthesis of RNA which carries the code for constructing a protein.

(i) Give **two** differences between DNA and RNA molecules.

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

(ii) Outline how DNA is able to **replicate** genetic information.

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

[Total: 11]

END OF QUESTION PAPER

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