OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE **2849/01**

CHEMISTRY (SALTERS)

Chemistry of Materials

TUESDAY 23 JANUARY 2007 Morning

Time: 1 hour 30 minutes

Candidates answer on the question paper.
Additional materials: Scientific calculator
Data Sheet for Chemistry (Salters) (Inserted)

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 will 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 (Salters)* 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	13	
2	20	
3	21	
4	17	
5	19	
TOTAL	**90**	

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

[Turn over

Answer **all** the questions.

1 Although natural silks from insects have been used for thousands of years it is only recently that the silk from spiders has been investigated. Chemists are always trying to develop materials that are stronger or lighter or tougher than materials currently in use.

As part of this development we need to find out the structure of the actual protein in silk.

(a) Silk, like all proteins, has three levels of structure: primary, secondary and tertiary.

Describe briefly these three levels of structure.

primary .....

.....

secondary .....

.....

tertiary .....

..... [3]

(b) The protein in silk can be broken down into its constituent amino acids.

(i) Give the reagent and conditions for breaking down a protein into its constituent amino acids.

reagent .....

conditions ..... [2]

(ii) What technique would you use in a laboratory to identify the amino acids present?

..... [1]

(c) Spider's silk has one of the highest tensile strengths of all fibres. One manufactured silk is even called BioSteel. The exceptional strength of BioSteel silk is due to the large number of alanine units in the protein chain producing highly crystalline fibres.

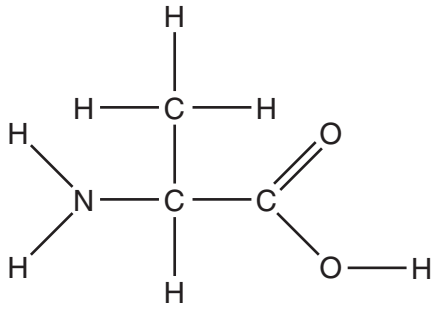
(i) Why are crystalline polymers strong?

.....

..... [1]

Alanine is a white crystalline solid which melts at 297 °C.

The structure of alanine is shown below.



The structure of alanine in the solid is slightly different from this structure.

(ii) Draw the zwitterion present in solid alanine.

[1]

(iii) Explain how the zwitterion accounts for the high melting point of solid alanine.

.....

..... [1]

(iv) Draw the structure of the peptide produced when two alanine molecules react together.

Circle the peptide (secondary amide) linkage.

[2]

(v) Alanine can exist as two stereoisomers.

The protein in BioSteel silk is made from its constituent amino acids by an enzyme reaction.

Explain why some alanine molecules are **not** incorporated into the protein in this enzyme reaction.

.....

.....

..... [2]

[Total: 13]

2 It is thought that using virgin olive oil in cooking reduces the risk of cancer from free radicals.

Chemists have shown that the oil contains tyrosol and hydroxytyrosol, which are strong scavengers of free radicals.

(a) A mixture of these two liquid compounds, tyrosol and hydroxytyrosol, is extracted from olive oil.

Describe how you would carry out thin layer chromatography to show that there are two compounds in a mixture.

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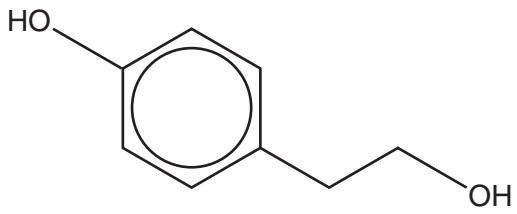
..... [5]

(b) The structure of tyrosol is given below.



Give the structures of **all** the products formed when tyrosol is reacted with:

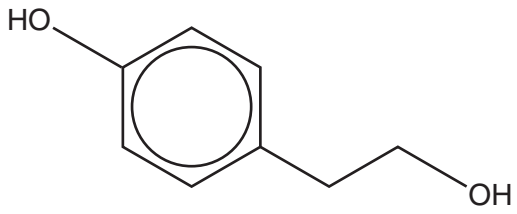
(i) aqueous sodium hydroxide

[2]

(ii) excess ethanoyl chloride.

[3]

(c) The presence of the oxygen atoms in the structure of tyrosol gives rise to two peaks in its infrared absorption spectrum.



(i) Complete the table below with the frequency of absorption giving rise to the two peaks, and state the bond responsible for each absorption.

wavenumber/cm^{-1}	bond

[2]

(ii) One of the two hydroxyl groups in tyrosol reacts with iron(III) chloride solution.

State the colour of the solution formed in the reaction.

..... [1]

(d) Tyrosol is a weak acid.

Use the equations below and the structures of the ions to explain why tyrosol is a weaker acid than ethanoic acid.

The structure of tyrosol is represented by TOH.

$$TOH \rightleftharpoons TO^- + H^+$$

$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

.....

.....

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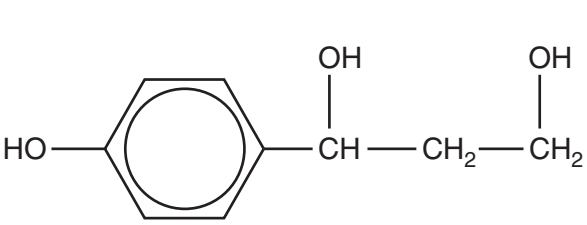
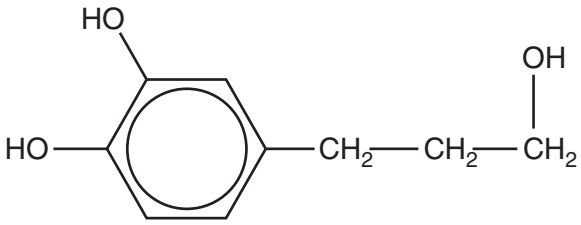
..... [3]

(e) Hydroxytyrosol has a similar structure to tyrosol but has three –OH groups instead of two.

(i) By considering the different positions of the –OH groups, explain how a proton n.m.r. spectrum can distinguish between the structures **C** and **D**.



C



D

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.....

.....

.....

..... [2]

(ii) Compound **C** is reacted with ethanoic acid in the presence of concentrated sulphuric acid.

Give the structural formula of the organic product.

[2]

[Total: 20]

3 Old mine workings are often the cause of the pollution of mountain streams. One of the main chemical culprits of such pollution is iron pyrites, FeS_2, in which iron has an oxidation state of +2. The early miners unwittingly accelerated the chemical processes by grinding up unwanted rock containing some ore and dumping it in waste heaps.

(a) Air and rain combine to oxidise iron pyrites.

Complete the balancing of the equation for this reaction.

…… $FeS_2(s) + 7O_2(g) + 2H_2O(l) \rightarrow$ …… $Fe^{2+}(aq)$ + …… $SO_4^{2-}(aq)$ + …… $H^+(aq)$

[1]

(b) The resulting ions then run off into the local streams where the iron(II) ions are oxidised.

(i) Using the data below explain why the water in the streams must be acidic for oxygen to oxidise the iron(II) ions.

half-reaction	$E^{\ominus}$/V
$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$	+0.40
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.77
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	+1.23

.....

.....

.....

.....

..... [3]

(ii) Use the appropriate data from the table above to write an equation for the oxidation of iron(II) ions in the stream water under acidic conditions.

$\rightarrow$

[2]

(c) Iron(III) ions are present in the stream as complex ions.

Complete the following table about these complex ions.

name of ligand in complex	
coordination number of complex	
name of shape of complex	

[3]

(d) The iron(III) ions are hydrolysed in the stream to form a precipitate, referred to as 'yellow boy' by the miners.

(i) What compound gives rise to the yellow colour of 'yellow boy'?

..... [1]

(ii) The hydrolysis can be represented by the following equations:

$$[Fe(H_2O)_6]^{3+}(aq) \rightleftharpoons [Fe(H_2O)_5(OH)]^{2+}(aq) + H^+(aq) \quad \textbf{equation 3.1}$$

$$[Fe(H_2O)_5(OH)]^{2+}(aq) \rightleftharpoons [Fe(H_2O)_4(OH)_2]^{+}(aq) + H^+(aq) \quad \textbf{equation 3.2}$$

$$[Fe(H_2O)_4(OH)_2]^{+}(aq) \rightleftharpoons Fe(OH)_3(s) + 3H_2O(l) + H^+(aq) \quad \textbf{equation 3.3}$$

1. Write the expression for the equilibrium constant, K_c, for the reaction represented by **equation 3.1**.

2. What data would you need in order to be able to comment on the effect of temperature on the value of the equilibrium constant?

.....

3. Explain why the reaction represented by **equation 3.3** goes almost to completion.

.....

..... [3]

(e) As a result of the increased acidity of the stream water, other d-block metal ions are leached into the water. Zinc(II) ions are often found in the water but are not noticed because they are colourless.

What feature of d-block metal ions enables some to be coloured in solution?

..... [1]

(f) Very dilute solutions of iron(III) ions are almost colourless. Addition of potassium thiocyanate leads to a deep red coloured complex.

(i) What type of reaction occurs?

..... [1]

(ii) What technique would you use to determine the concentration of the complex formed?

..... [1]

(g) Another way to measure the concentration of iron(III) ions in solution is to carry out a titration. The iron(III) ions are first reduced to iron(II) ions and then an acidified sample is titrated with a standard potassium manganate(VII) solution.

The equation for the titration reaction is given below.

$$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \longrightarrow 5Fe^{3+} + Mn^{2+}(aq) + 4H_2O(l)$$

(i) Name a suitable acid to acidify the sample.

..... [1]

(ii) 25.0 cm^3 of an iron(II) solution is titrated with a 0.0100 mol dm^{-3} MnO_4^- solution.

The average titre is 16.60 cm^3.

Calculate the concentration of the iron(II) solution.

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

concentration = ... mol dm^{-3} [3]

(iii) How can you tell when the titration reaches its end point?

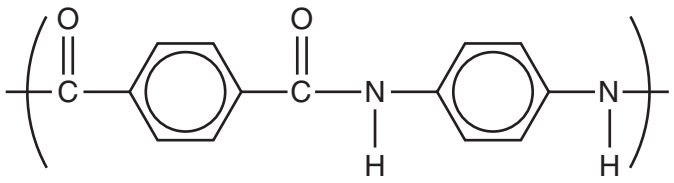
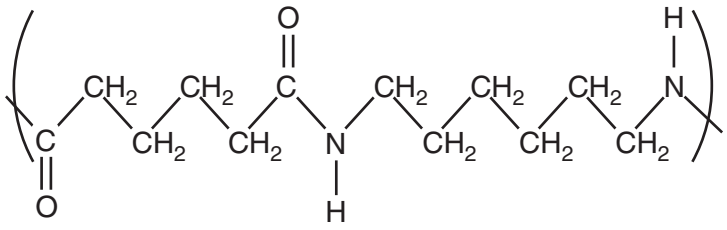
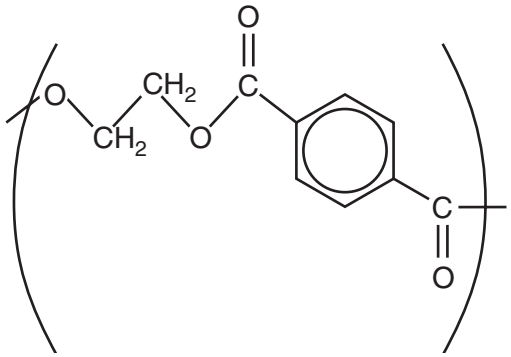
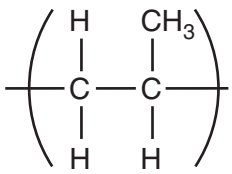
.....

..... [1]

[Total: 21]

4 Ropemakers, who supply products for the modernisation of working sailing ships, have recently started to make synthetic ropes.

The repeating units of four polymers used in their products are shown in the table below.

polymer listed in order of decreasing tensile strength	repeating unit	type of polymerisation
E		
F		
G		
H		

(a) Complete the table by stating the type of polymerisation by which each polymer is formed. [2]

(b) Name the functional group joining the monomer units in polymer **G**.

..... [1]

(c) Polymer **H** is used as a replacement for hemp, a natural fibre.

At the end of a rope's useful life, it has to be disposed of.

Suggest one **advantage** that hemp has over polymer **H** in terms of the method of disposal.

.....

..... [1]

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

A rope for a particular purpose needs to have a minimum tensile strength.

The order of the polymers' strengths is shown in the table.

Discuss, in terms of the different types of intermolecular interactions, the reasons for this order and why polymer **E** is by far the strongest polymer.

.....

.....

.....

.....

.....

.....

.....

.....

..... [5]

Quality of Written Communication [1]

(e) **(i)** Give the reagent and conditions for hydrolysing polymer **G**.

reagent .....

conditions ..... [2]

(ii) Draw the structural formulae of the two organic products formed from the reaction in **(i)**.

[2]

(f) In Arctic conditions many polymers become unsuitable for use as ropes.

Suggest and explain why.

.....

.....

.....

..... [3]

[Total: 17]

5 Rhodium and cobalt have many important catalytic uses. For example rhodium is an important component of catalytic converters for car exhausts. Rhodium compounds are used as homogeneous catalysts to make ethanoic acid from methanol.

(a) (i) Rhodium atoms have an outer electron structure of $4d^8\ 5s^1$.

Suggest **two** ways in which the outer electron structure for a cobalt atom is different from the outer electron structure for a rhodium atom.

.....

..... [2]

(ii) Explain why rhodium and cobalt are able to act as catalysts.

.....

.....

..... [2]

(iii) What essential property must the rhodium compounds have to act as **homogeneous** catalysts in the manufacture of ethanoic acid?

..... [1]

(b) One of the reactions which takes place in a catalytic converter is given below.

$$NO(g) + CO(g) + O_2(g) \rightarrow NO_2(g) + CO_2(g)$$

(i) Suggest **one** way that the rate of this reaction could be monitored. Give a reason for your choice.

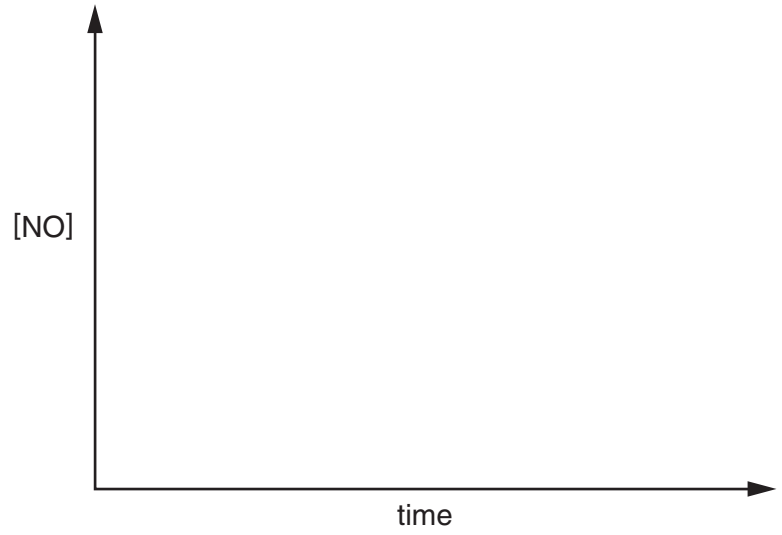
.....

.....

..... [2]

(ii) On the axes below sketch a graph to show how the concentration of NO would vary as the reaction proceeded.

Show on your graph how you would measure the initial rate of reaction with respect to NO.



.....

..... [4]

(c) An investigation to measure the rate of the reaction in **(b)** gave the following four results.

	initial concentration			
experiment	[NO] / 10^{-4} mol dm^{-3}	[CO] / 10^{-4} mol dm^{-3}	[O_2] / 10^{-4} mol dm^{-3}	initial rate / 10^{-4} mol dm^{-3} s^{-1}
1	2.50	2.50	2.50	5.0
2	2.50	5.00	2.50	5.0
3	5.00	5.00	2.50	20.0
4	5.00	5.00	5.00	20.0

(i) Give the order with respect to each of the reactants.

[NO] …… [CO]…… [O_2]…… [3]

(ii) Write a rate equation for the reaction.

..... [2]

(iii) Calculate a value for the rate constant of the reaction under the conditions used in the investigation.

State the units of the rate constant.

rate constant = ...

units ..... [3]

[Total: 19]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE