OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE **2849/01**

CHEMISTRY (SALTERS)

Chemistry of Materials

THURSDAY 12 JUNE 2008 Afternoon

Time: 1 hour 30 minutes

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

CUP/T46185

Candidate Forename		Candidate Surname	
Centre Number		Candidate Number	

INSTRUCTIONS TO CANDIDATES

- Write your name in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use blue or black ink. Pencil may be used for graphs and diagrams only.
- Read each question carefully and make sure that you know what you have to do before starting your answer.
- Answer **all** the questions.
- Do **not** write in the bar codes.
- Write your answer to each question in the space provided.

INFORMATION FOR CANDIDATES

- The number of marks for each question is given in brackets [ ] at the end of each question or part question.
- The total number of marks for this paper is **90**.
- 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.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**10**	
2	**26**	
3	**14**	
4	**17**	
5	**23**	
TOTAL	**90**	

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

[Turn over

Answer **all** the questions.

1 Butanoic acid has a very unpleasant smell and foul taste. It is found in human sweat and parmesan cheese.

(a) Give the structural formula of butanoic acid.

[1]

(b) Butanoic acid reacts with methanol to form an ester, **A**, which has a pleasant odour. This compound is used in perfumes.

(i) Draw the structure of compound **A**.

[1]

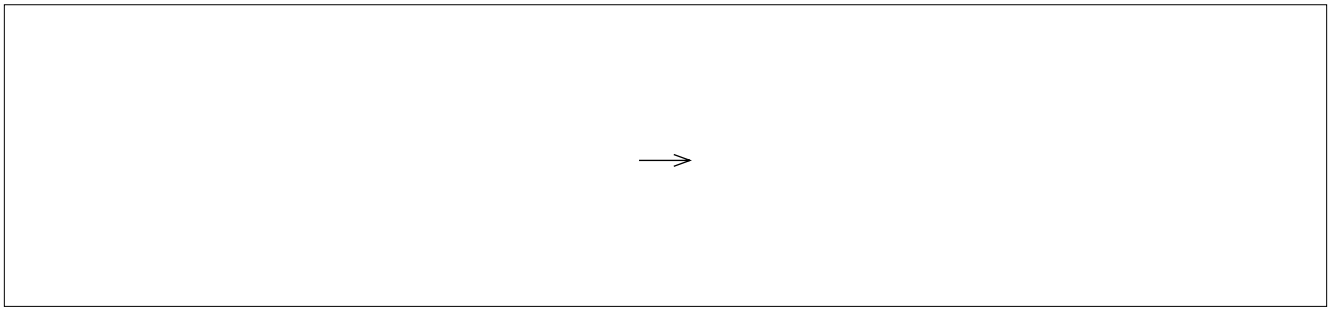
(ii) Give the catalyst and the conditions used to convert butanoic acid and methanol into compound **A**.

catalyst .....

conditions .....[2]

(c) A spillage of butanoic acid can be neutralised using excess powdered calcium carbonate.

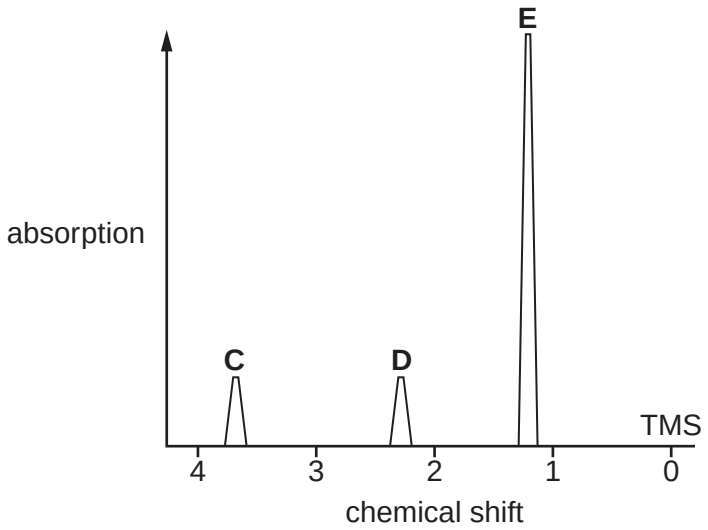
Write a balanced equation for the reaction that occurs.



[2]

(d) Another sweet smelling ester is made from butanoic acid by reacting it with an alcohol, C_3H_7OH.

The proton n.m.r. spectrum of the alcohol is represented in the diagram below.



(i) Draw the structural formulae of the two alcohols with formula C_3H_7OH.

[2]

(ii) Use the n.m.r. spectrum above to decide which of the isomers in **(i)** produced the spectrum. Explain your answer.

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.....

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.....[2]

[Total: 10]

2 Hair is made of strands of a protein called keratin. In order to understand the chemistry involved in colouring hair using hair dyes, the structure of keratin needs to be determined.

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

Keratin has three levels of structure: primary, secondary and tertiary. It can be broken down into its constituent amino acids.

- Give the meaning of each of the three terms used to describe the levels of protein structure.
- Describe how keratin can be broken down in a school laboratory.

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.....[5]

Quality of Written Communication [1]

(b) Describe how paper chromatography and ninhydrin, a locating agent, are used to show which amino acids are present in an aqueous mixture. You should include a labelled diagram in your answer.

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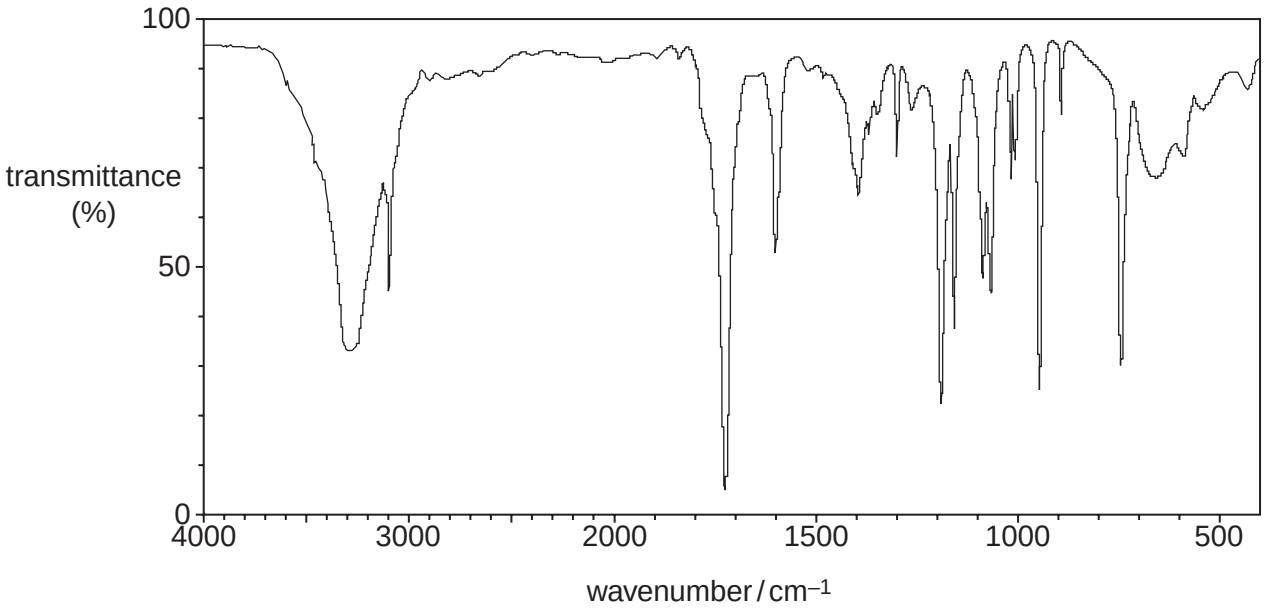
.....[5]

(c) The infrared spectrum of ninhydrin is shown below.



(i) Ninhydrin contains the functional groups C=O (ketone) and OH (alcohol). Label on the infrared spectrum above an absorption peak corresponding to each of these groups. [2]

(ii) What happens to molecules when they absorb infrared radiation?

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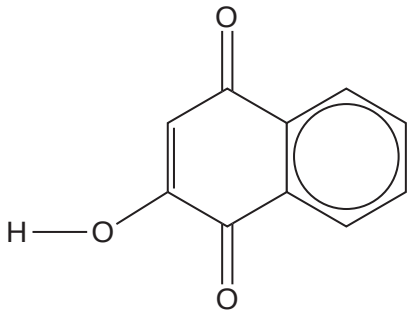
.....[2]

(d) A hair colouring compound used by the ancient Egyptians, and still in use, is 'lawsone'. The structure of lawsone is shown below.



(i) The hydroxyl group in lawsone reacts like a phenol rather than an alcohol.

Describe a chemical test to show the presence of a phenol and give the observation expected.

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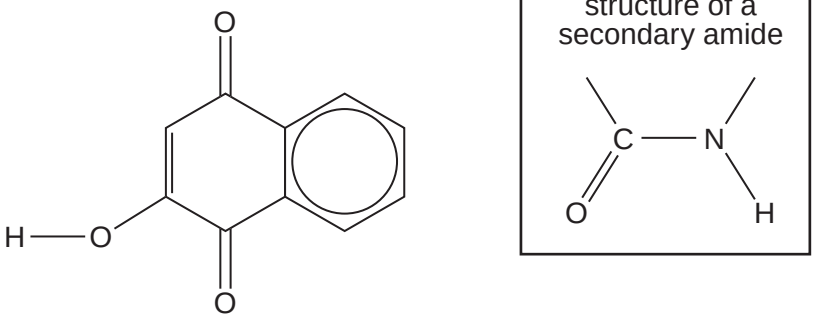
.....[2]

(ii) Lawsone binds to hair by forming hydrogen bonds to keratin.



Show, by drawing on the diagram above, how a secondary amide group in a keratin molecule can hydrogen bond to the hydroxyl group in lawsone.

Label any relevant lone pairs and partial charges. [3]

(e) Modern hair colouring compounds use a system in which small molecules are reacted together to form the hair dye. Hydrogen peroxide is often used in the process.

Hydrogen peroxide solutions are unstable and decompose on standing.

The table below shows the results of an experiment to measure the rate of the decomposition of hydrogen peroxide.

time / $\times 10^6$ s	$[H_2O_2]$ / mol dm^{-3}
0.0	9.00
1.0	4.50
2.0	2.25
3.0	1.13

(i) What is the order of the decomposition reaction?

Give your reasoning.

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.....[2]

(ii) Give the rate equation for the decomposition reaction.

.....[1]

(iii) The initial rate of the reaction is 6.24×10^{-6} mol dm^{-3} s^{-1}.

Calculate the rate constant for the reaction.

State the units of the rate constant.

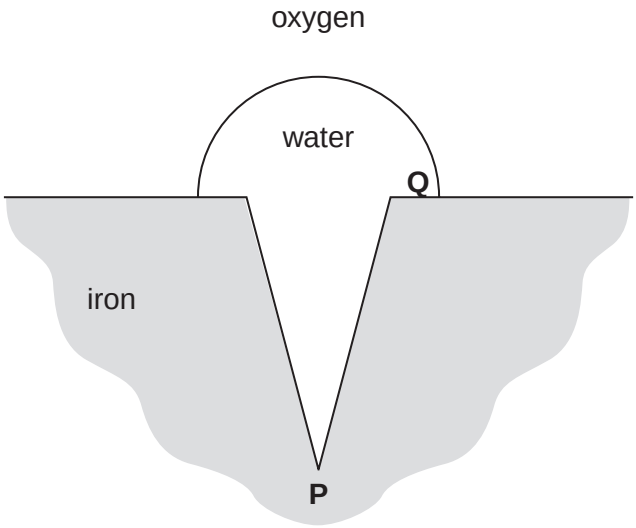
rate constant = ...

units = ...
[3]

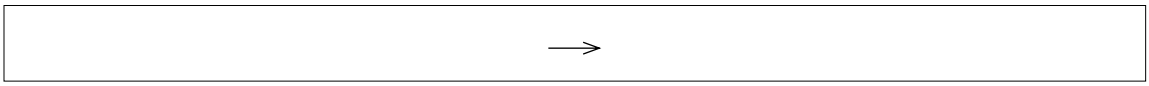
[Total: 26]

3 An increasingly important method of protecting steel from rusting is to coat it with zinc and then with an organic polymer.

(a) Rusting is a result of electrochemical processes. The diagram below shows a water droplet on the surface of a piece of iron metal. **P** is at the bottom of a small indent on the surface.

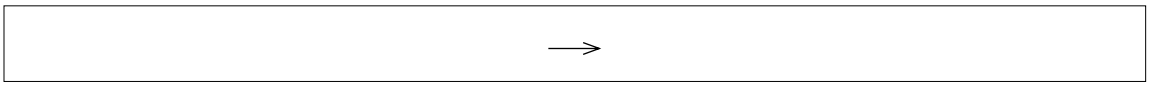


(i) Write the half-equation for the reaction of **iron** that occurs at **P**.



[1]

(ii) Write the half-equation for the reaction between oxygen and water that occurs at **Q**.



[2]

(iii) The ions formed in these two reactions can form a precipitate.

Give the chemical name, or formula, of the compound formed.

.....[1]

(iv) Draw an arrow on the diagram to show how electrons are transferred between **P** and **Q** in the rusting process. [1]

(b) Coating steel with zinc prevents rusting in a different way from coating with an organic polymer.

Describe and explain this difference.

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.....[3]

(c) The amount of iron in rust can be determined by carrying out a redox titration using potassium manganate(VII). A sample of rust is reacted with acid and the resulting aqueous Fe^{3+} ions are then reduced to Fe^{2+}.

A portion of the Fe^{2+} solution is titrated with a solution of potassium manganate(VII) of known concentration.

(i) State the colour change that occurs at the end point.

.....[1]

(ii) 1.800 g of rust is made into 250.0 cm^3 solution containing Fe^{2+}.

25.0 cm^3 of this solution reacts with 35.0 cm^3 of 0.0100 mol dm^{-3} potassium manganate(VII) solution.

The equation for the reaction is given below.

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

Calculate the percentage of iron by mass in the sample of rust. Give your answer to the **appropriate** number of significant figures.

A_r: Fe, 55.9

percentage of iron = ... % [5]

[Total: 14]

4 A blue ink can be made using an intense blue pigment, Prussian Blue.

Prussian Blue is formed when an iron(II) salt is added to a solution containing $[Fe(CN)_6]^{3-}$ ions.

The cyanide ion has the formula CN^-.

(a) (i) What is the oxidation state of Fe in the $[Fe(CN)_6]^{3-}$ ion?

..... [1]

(ii) Using the structure $NC:^-$ to represent a cyanide ion, draw a diagram to show the shape of a $[Fe(CN)_6]^{3-}$ ion. Show clearly how the ligands bond to the central ion.

[2]

(b) A solution containing $[Fe(CN)_6]^{3-}$ ions can be made from $[Fe(H_2O)_6]^{2+}$ ions in two steps, as shown below.

step 1 $[Fe(H_2O)_6]^{2+}(aq) + 6CN^-(aq) \rightleftharpoons [Fe(CN)_6]^{4-}(aq) + 6H_2O(l)$

step 2 $[Fe(CN)_6]^{4-}(aq) \longrightarrow [Fe(CN)_6]^{3-}(aq) + e^-$

(i) Name the type of reaction taking place in **step 1**.

.....[1]

(ii) The reaction in **step 1** can be written as:

$$Fe^{2+}(aq) + 6CN^-(aq) \rightleftharpoons [Fe(CN)_6]^{4-}(aq)$$

Write the expression for the equilibrium constant, K_{stab}, for this reaction.

K_{stab} =

[2]

(iii) What additional information would you require about the reaction in **step 1** to be able to describe the effect that temperature would have on the value of K_{stab}?

.....[1]

(iv) In a further experiment, excess hydroxide ion is added instead of excess cyanide ion in **step 1**.

Describe what you would see and give an ionic equation for the reaction which occurs. Include state symbols.

observation .....

$\longrightarrow$

[3]

(v) The table below contains some data for standard electrode potentials.

half-reaction	$E^{\ominus}$/V
$Zn^{2+}(aq) + 2e^- \longrightarrow Zn(s)$	–0.76
$[Fe(CN)_6]^{3-} + e^- \longrightarrow [Fe(CN)_6]^{4-}(aq)$	+0.36
$Cl_2(aq) + 2e^- \longrightarrow 2Cl^-(aq)$	+1.36

Use these data to decide on a suitable reagent to use to convert $[Fe(CN)_6]^{4-}$ ions to $[Fe(CN)_6]^{3-}$ ions in **step 2**. Explain your choice.

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.....[3]

(c) Prussian Blue has an intense blue colour.

Why do blue compounds appear blue?

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.....[2]

(d) Prussian Blue is used as a medicine to remove radioactive caesium from the human body.

Describe **two** factors that would be investigated in the first human clinical trials of Prussian Blue.

1 .....

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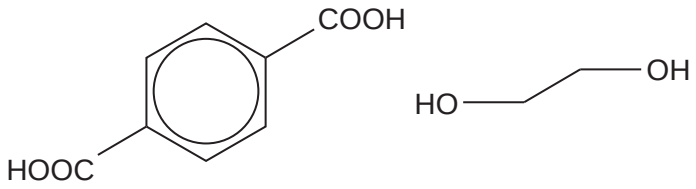
2 .....

.....[2]

[Total: 17]

5 Polymer films made from 'PET' are often used for food packaging. PET is made from the monomers **F** and **G**. The structures of **F** and **G** are shown below.



F **G**

(a) **(i)** Draw the repeating unit for PET.

[2]

(ii) The process in which **F** and **G** form PET is called condensation polymerisation.

Explain how condensation polymerisation is different from addition polymerisation.

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.....[2]

(b) Food packaging materials must be strong enough not to be easily damaged. Film made from PET is much stronger than that made using poly(ethene).

Explain, in terms of the types of intermolecular forces present, why this is so.

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.....[3]

(c) During refrigeration, packaging films have to withstand low temperatures.

(i) The temperature of a polymer is lowered below its glass transition temperature.

Describe the effect of this on the properties of the polymer.

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.....[1]

(ii) Explain your answer to **(i)** using ideas of polymer chains and energy.

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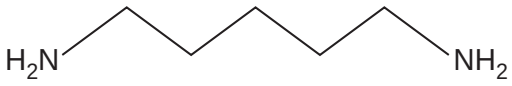
.....[3]

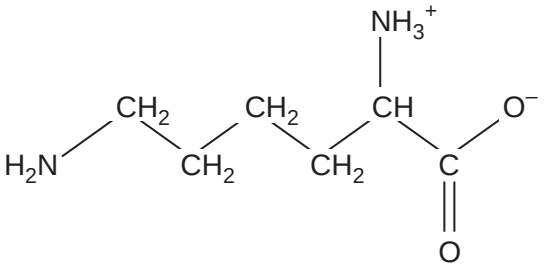
(d) One of the problems of packaging fish and meat products is the gradual build up of foul smelling odours. A compound responsible for such smells is 'cadaverine'. Its structure is shown below.



Give the systematic chemical name for cadaverine.

.....[2]

(e) Cadaverine is produced by the decomposition of proteins which contain one of the enantiomers of the amino acid lysine. Lysine is soluble in water. The structure of lysine is shown below.



(i) Draw a circle around the carbon atom in lysine responsible for it having enantiomers. [1]

(ii) Would you expect an aqueous solution of lysine to be acidic, neutral or alkaline?

Explain your choice.

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.....[2]

(iii) A sample of lysine is analysed using a mass spectrometer. One of the peaks in the spectrum occurs at a mass of 30.

Suggest the formula for the ion responsible for the peak at this mass in the mass spectrum of lysine.

[2]

(f) Chemists are developing films which contain additives to oxidise compounds such as cadaverine when they come into contact with the film. The products are odourless and non-toxic. One of the additives is an iron(II) salt, which acts as a catalyst for the oxidation.

(i) Complete the electron configurations for Fe(II) and Fe(III) ions.

Fe(II) ion $1s^2\ 2s^2\ 2p^6$ .....

Fe(III) ion $1s^2\ 2s^2\ 2p^6$ .....[2]

(ii) Explain how Fe(II) ions act as catalysts in some redox reactions.

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.....[3]

[Total: 23]

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE