THIS IS A LEGACY SPECIFICATION

OCR
RECOGNISING ACHIEVEMENT

ADVANCED GCE

CHEMISTRY (SALTERS)

Chemistry of Materials

2849/01

CUP/T73440

Candidates answer on the question paper
A calculator may be used for this paper

OCR Supplied Materials:
- *Data Sheet for Chemistry (Salters)* (Inserted)

Other Materials Required:
- Scientific calculator

Tuesday 20 January 2009
Morning

Duration: 1 hour 30 minutes

2849/01

Candidate Forename		Candidate Surname	

Centre Number						Candidate Number				

INSTRUCTIONS TO CANDIDATES

- Write your name clearly in capital letters, your Centre Number and Candidate Number in the boxes above.
- Use 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, however additional paper may be used if necessary.

INFORMATION FOR CANDIDATES

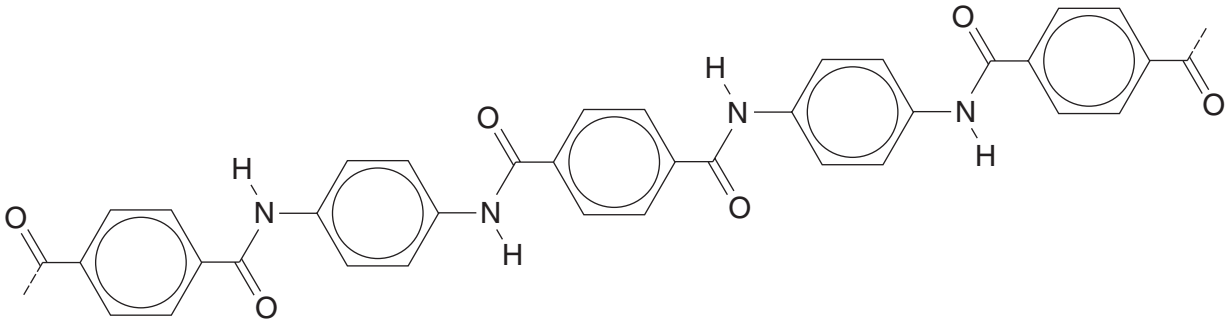
- The number of marks is given in brackets **[ ]** at the end of each question or part question.
- The total number of marks for this paper is **90**.
- You will be awarded marks for the quality of written communication where this is indicated in the question.
- You may use a scientific calculator.
- You may use the *Data Sheet for Chemistry (Salters)*.
- You are advised to show all the steps in any calculations.
- This document consists of **20** pages. Any blank pages are indicated.

FOR EXAMINER'S USE		
Qu.	**Max.**	**Mark**
1	**18**	
2	**18**	
3	**16**	
4	**21**	
5	**17**	
TOTAL	**90**	

OCR is an exempt Charity

Answer **all** the questions.

1 Twaron is a heat-resistant, high-strength fibre used in protective clothing. The structure of the polyamide chain in Twaron is shown below.



(a) (i) Twaron is made from two monomers. In the boxes below draw the structural formula of each monomer.

Name the functional group, other than benzene, present in each monomer.

functional group ..... functional group .....

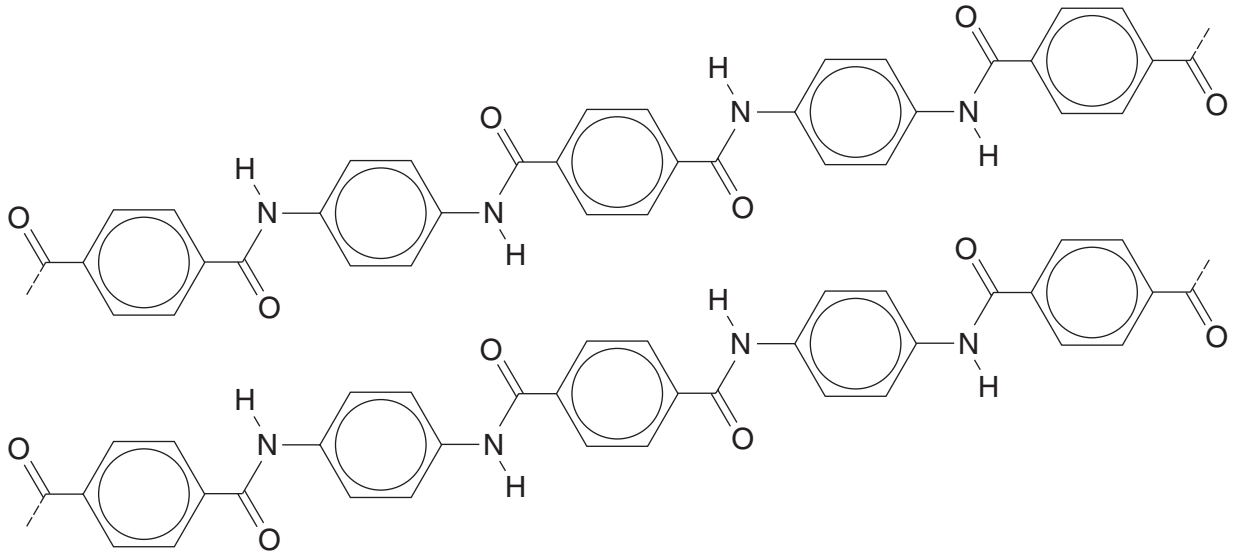
[4]

(ii) **On the above diagram of the polyamide chain** draw a circle around the repeating unit.

[1]

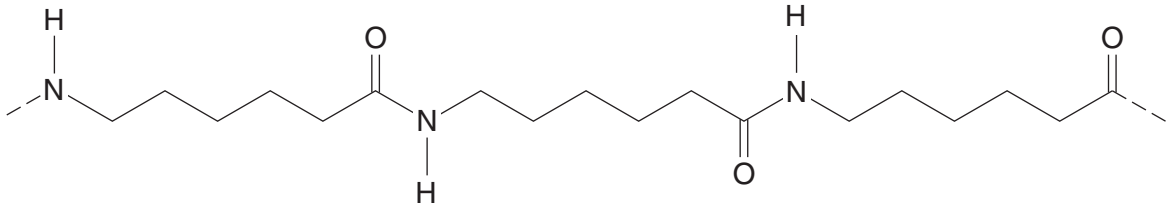
(b) On the diagram below of two adjacent polyamide chains, show **one** way in which hydrogen bonding can occur between the chains.

Show any relevant partial charges and lone pairs of electrons.



[3]

(c) Hydrogen bonding also occurs in other types of polyamides, such as nylon-6. The structure of a polymer chain for nylon-6 is shown below.



(i) Unlike in nylon-6, the molecules of Twaron are flat.

Suggest and explain how this would affect the strength of Twaron compared with nylon-6.

.....

.....

.....

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

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

Polymers such as Twaron and nylon-6 are affected by very low **and** very high temperatures.

Describe and explain how the properties of polymers change at low **and** high temperatures.

.....

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.....

.....

.....

..... **[5]**

Quality of Written Communication **[1]**

(d) Twaron can be broken down into its monomers.

Name a suitable reagent and give the conditions required for doing this.

reagent .....

conditions .....
[2]

[Total: 18]

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2 Heating chilli peppers under reflux with ethanol produces a liquid that can be used as a spicy sauce.

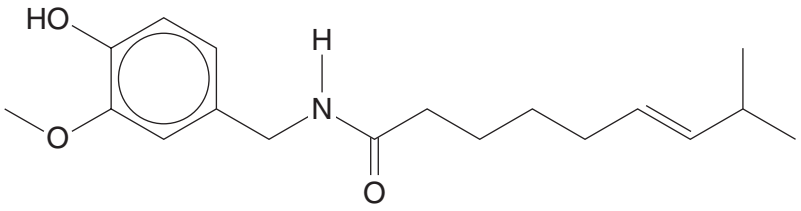
(a) Explain what is meant by *heating under reflux.*

.....

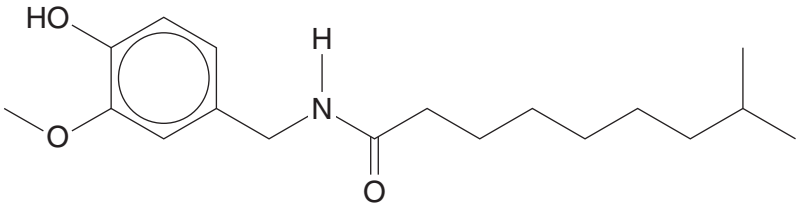
.....

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

(b) Several compounds are responsible for the burning sensation of chilli peppers. The two most important of these are capsaicin and a compound known as DHC.



capsaicin



DHC

(i) Describe and explain **one** way in which the mass spectra of these two compounds will differ.

.....

.....

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

(ii) Proton nmr spectra can be used to distinguish between capsaicin and DHC.

Describe and explain two key differences in the spectra which would allow you to distinguish between them.

Give details of any spectroscopic data used.

.....

.....

.....

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

(iii) Both compounds contain a hydroxyl group. Suggest how you would use the infrared spectra of these compounds to show this. Give details of any peak you would use.

.....

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

(iv) Describe a chemical test for a hydroxyl group directly attached to a benzene ring.

reagent used .....

observations made ..... **[2]**

(c) Homocapsaicin, a geometric isomer of capsaicin, is also found in chilli peppers.

(i) What term would be used in the systematic name of **capsaicin** to distinguish it from homocapsaicin?

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

(ii) Explain why capsaicin can have a geometric isomer.

.....

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

(d) Capsaicin can be hydrolysed. The rate of this reaction can be determined by measuring the change in concentration of $H^+(aq)$.

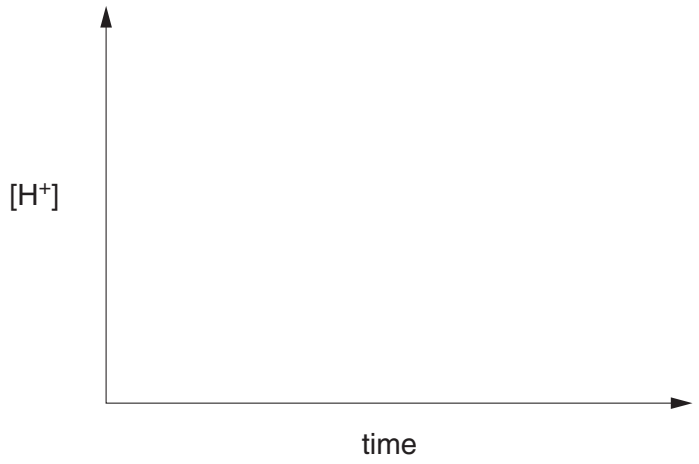
(i) Give one method of measuring the $H^+(aq)$ concentration.

.....

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

(ii) In a hydrolysis experiment the concentration of H^+ ions was found to decrease. The experiment showed that the reaction was first order with respect to H^+.

On the diagram below sketch a graph of how you would expect the H^+ ion concentration to change with time.



[1]

(iii) Describe how you would use the graph in **(ii)** to determine how the rate varies during the course of the reaction.

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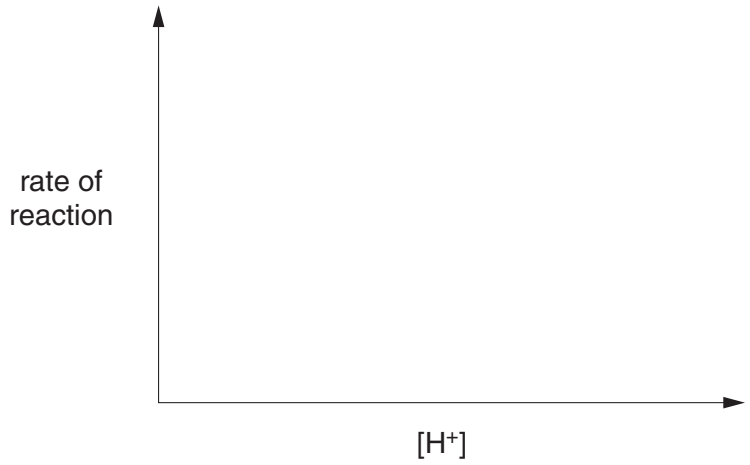
.....

.....

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

(iv) On the diagram below, show how the rate of reaction varies with $[H^+]$ for a first order reaction.



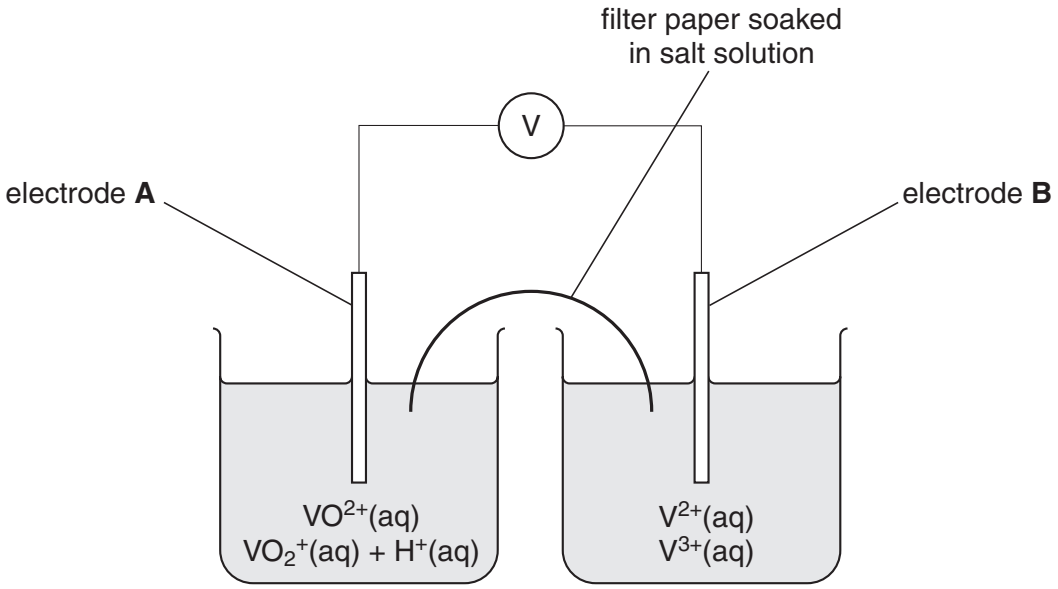
[1]

[Total: 18]

3 Vanadium half-cells are widely used to construct very large, rechargeable batteries.

The technology relies on the ability of vanadium to exist in several different oxidation states.

(a) The diagram below represents a laboratory-scale version of the commercial cell. Sulphuric acid is also added to the aqueous solutions of vanadium ions in each half-cell.



(i) Give the oxidation state of vanadium in a VO_2^+ ion.

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

(ii) Name a suitable metal which could be used for both electrodes **A** and **B**.

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

(iii) Name a suitable solution which could be used for soaking the filter paper.

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

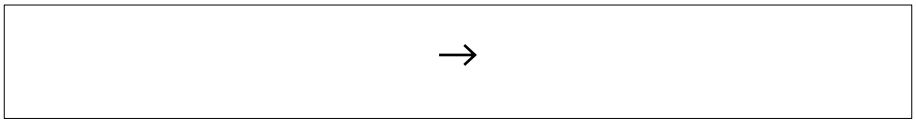
(iv) Using data from **Table 1**, calculate the $E^{\ominus}_{cell}$ value for the cell shown in the diagram.

Table 1

half-reaction	$E^{\ominus}$/V
$V^{3+} + e^- \rightarrow V^{2+}$	–0.26
$VO^{2+} + 2H^+ + e^- \rightarrow V^{3+} + H_2O$	+0.34
$O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$	+0.68
$VO_2^+ + 2H^+ + e^- \rightarrow VO^{2+} + H_2O$	+1.00

$E^{\ominus}_{cell}$ = ... V **[1]**

(v) Write an overall equation for the reaction taking place in the cell shown opposite, when it is producing a current. State symbols are not required.



[2]

(b) The various vanadium ions have different colours in solution as shown in **Table 2**.

Table 2

V^{2+}	lavender/pale purple	VO_2^+	yellow
V^{3+}	green	VO^{2+}	blue

Oxygen is bubbled, under standard conditions, through an acidified solution containing V^{2+} ions.

(i) Using the data from **Tables 1** and **2**, predict the final colour of the solution after bubbling oxygen through it.

Show clearly how you used the data in working out your answer.

.....

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.....

.....

final colour of solution ..... **[4]**

(ii) Explain why the solution containing the V^{2+} ions is acidified before bubbling the oxygen through it.

.....

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

(c) V^{3+} ions are present in aqueous solution as complex ions with the formula $[V(H_2O)_6]^{3+}$. They react with chloride ions to form $[VCl_4]^-$ ions.

(i) What type of reaction is taking place in this conversion?

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

(ii) Name the type of bonding between vanadium and the ligands in these two complex ions.

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

(iii) Complete the table below to identify the coordination number and a **possible** shape for each of the complex ions.

formula of complex ion	coordination number	name of shape of complex ion
$[V(H_2O)_6]^{3+}$		
$[VCl_4]^-$		

[3]

[Total: 16]

4 Power showers often produce dark brown-coloured water when first switched on after being unused for a few days. The discolouration in the water is due to the formation of iron(III) hydroxide caused by rusting of the steel shower parts.

(a) The formation of 'rust' takes place in three stages in the presence of air and water.

stage 1 iron metal forms aqueous Fe^{2+} ions

stage 2 Fe^{2+} ions are oxidised

stage 3 iron(III) hydroxide is precipitated out of solution

(i) Write the half-equation for the formation of Fe^{2+} ions from Fe in **stage 1**.

→

[1]

(ii) Write the half-equation for the formation of OH^- ions from O_2 and H_2O.

Include state symbols.

→

[2]

(iii) Name the oxidising agent in **stage 2**.

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

(iv) Write an ionic equation for the precipitation reaction in **stage 3**.

→

[2]

(b) The amount of $Fe^{2+}(aq)$ in a sample of water can be found by titration with a standard solution of potassium manganate(VII).

(i) $25.0\,cm^3$ of an acidified solution containing $Fe^{2+}(aq)$ reacts exactly with $15.0\,cm^3$ of $0.00500\,mol\,dm^{-3}$ potassium manganate(VII). The equation for the reaction is given below.

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

Calculate the concentration of $Fe^{2+}(aq)$ in the sample.

answer = ... $mol\,dm^{-3}$ **[3]**

(ii) Why does an indicator **not** need to be added for this titration?

.....

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

(c) Salts made from a carboxylic acid are used in stain removers to treat clothes. Although the acid itself will remove iron stains it cannot be used with clothes made from wool.

(i) Alcohols and carboxylic acids both contain an –OH group in their structures.

Explain why carboxylic acids have acidic properties whereas alcohols do not.

.....

.....

.....

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

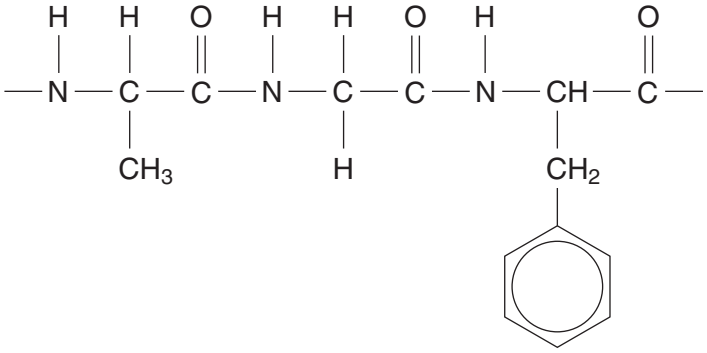
(ii) The structure of a carboxylic acid often used in stain removers is shown below.

Give the **full structural formula** of the salt formed by neutralising this acid with sodium hydroxide. Include the appropriate charges.

[2]

(iii) Wool fibres are made from proteins. Acids cause the protein polymer chains to break.

On the diagram draw a vertical line through the bond which would be broken by reaction with acid.



[1]

(iv) In the boxes below draw the functional groups which would form when **one bond** breaks in acid.

[2]

(v) The proteins in wool can also be broken by the digestive enzymes found in moth larvae.

These enzymes break the disulphide bridges found in wool proteins.

Explain why an enzyme is specific for the reaction it carries out.

.....

.....

.....

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

[Total: 21]

5 Biodiesel is becoming increasingly important as a fuel. It is made from vegetable oils such as rapeseed oil. These oils contain esters of long chain carboxylic acids. One process of converting these oils to biodiesel involves two stages.

stage 1
The esters react with sodium hydroxide to form sodium salts. These salts are converted into the corresponding carboxylic acids.

stage 2
The carboxylic acids then react with methanol to form methyl esters. The mixture of methyl esters is used as biodiesel.

(a) The two reactions taking place in **stage 1** can be illustrated using a simple ester with the formula $CH_3CH_2COOCH_2CH_3$.

(i) Give the chemical name of this ester.

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

(ii) Complete the equation below for the reaction of this ester with hydroxide ions.

$CH_3CH_2COOCH_2CH_3$ + $\rightarrow$

[3]

(iii) Give the reagent used to convert the sodium salts into the corresponding acids.

reagent ..... **[1]**

(iv) One of the acids produced from rapeseed oil in **stage 1** is linoleic acid, $C_{17}H_{33}COOH$.

Name the other substance that must be added for methanol to react with linoleic acid to form an ester.

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

(v) Draw the structure of the ester formed, showing the full structural formula of the ester linkage.

[2]

(b) The production of biodiesel requires large quantities of methanol. The equation for one catalytic method of manufacturing methanol is shown below. The reaction takes place at 500 K.

$$CO(g) + 2H_2(g) \rightleftharpoons CH_3OH(g)$$

(i) In the box below write the expression for the equilibrium constant, K_c, for this reaction.

State the units of K_c.

K_c =

units of K_c ..... **[2]**

(ii) The numerical value for the equilibrium constant, K_c, of the reaction is 14.5 at 500 K.

At equilibrium the concentrations of CO and H_2 are 0.0900 and 0.110 mol dm^{-3} respectively.

Calculate the equilibrium concentration of CH_3OH.

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

answer = ... mol dm^{-3} **[3]**

(iii) What does the size of the equilibrium constant, K_c, tell you about the position of equilibrium for this reaction?

.....

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

(iv) The reaction producing methanol is endothermic.

State the effect that increasing temperature and pressure have on the magnitude of the equilibrium constant, K_c, for the reaction.

temperature .....

.....

pressure .....

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

[Total: 17]

END OF QUESTION PAPER

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